Interventions to control Campylobacter in the broiler production

Report of an International Expert Consultation Copenhagen, Denmark, 26-27 November 2007

DTU Food
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Introduction

In the end of November 2007, an expert consultation concerning interventions strategies against *Campylobacter* in the broiler production was held in Copenhagen, Denmark. The aim of the consultation was to provide information and recommendations on the most useful interventions in the broiler production for reducing the human exposure to *Campylobacter* from broiler meat and thereby the number of human *Campylobacter* cases. The recommendations were meant to facilitate and guide the decision-making for a new Danish five-year action plan for *Campylobacter* in broilers and broiler meat. In Denmark, several voluntary initiatives to reduce the burden from *Campylobacter* have already been implemented in the broiler production. To reduce the occurrence of *Campylobacter* even further, a new action plan was recommended by the authorities. This was drafted ultimo 2007 and launched in the beginning of 2008. An outline of the approved action plan is included in this report.

A total of 25 invited experts, from eight countries, participated in the consultation. The experts were selected according to their expertise on interventions obtained from experimental studies, quantitative risk assessments and/or risk management.

First of all, the experts were asked to present experiences and results of relevant research. Secondly, the experts were split into groups and asked to identify and discuss the pros and cons of different intervention strategies and evaluate interventions in terms of effect, cost, applicability, and consumer acceptability. They were asked to prioritise and evaluate the interventions they believed to be most useful under Danish conditions. The conclusions of the expert consultation are, therefore, not necessarily applicable in other countries where the *Campylobacter* prevalence in broilers is different to that of Danish broilers or where different legislation applies, e.g. legislation on the use of chemical decontaminants.

Before and directly after the meeting, the individual experts were also asked to identify the top-three interventions that they believed should be prioritised to reduce *Campylobacter* in broilers.

Based on the group discussions it was concluded that priority should be given to biosecurity in and around the broiler houses, especially insect control. Results of a Danish study on insect control by using fly screens were considered very promising. Identification and decontamination of meat from positive flocks was also considered important. Freezing was considered to be among the most efficient methods for decontamination. However, because freezing limits the quantity of chilled fresh meat during periods with high *Campylobacter* prevalence, other methods of decontamination, or combinations of several methods, were preferred. Examples of

such methods were steam-ultrasound, crust freezing, and forced-air-chilling. Other suggested possibilities were allocation of meat for products that would be safe for the consumer to handle, for example oven-ready products in foil trays, whole chickens in roasting-bags or heat-treated, ready-to-eat products. Interventions aimed at reducing faecal contamination were also given high priority. Furthermore, education of consumers, especially children, and food handlers was considered important.

In the following, the intervention strategies that were discussed are described in more detail.

Quantitative Risk Assessment

Results of quantitative risk assessments carried out in the United Kingdom, the Netherlands, New Zealand and Sweden were presented. The conclusions of these risk assessments were surprisingly similar, despite the use of various modelling techniques. Similar to the results of the Danish risk assessment, all models concluded, that reducing the number of *Campylobacter* on chicken meat will have a significant effect on the number of human cases. The association between the reduction in flock prevalence and the calculated reduction in risk of human disease was estimated to be 1:1. Interestingly, the models all indicated that the risk of disease associated with *Campylobacter* in broilers, in particular is related to meat with high concentrations of *Campylobacter.*

Almost all models concluded that logistic slaughter, i.e. the practice of slaughtering *Campylobacter* positive flocks after the negative flocks, has very little effect on reducing the risk of human disease. In contrast, freezing of *Campylobacter* positive flocks is much more effective, because it reduces the number of *Campylobacter* on the meat (by approximately 2 $\log_{10}$ units). Furthermore, the Dutch risk assessment model also indicated heat treatment, radiation, crust-freezing and chemical decontamination as very effective means of reducing the number of *Campylobacter* on the meat. However, the most cost-effective intervention was considered to be reduction of faecal contamination during scalding and defeathering.

The Danish use of a risk assessment model for monitoring of foodstuffs (Danish and imported), also known as the case-by-case risk assessment, was presented. Denmark is the only country in EU performing this kind of systematic case-by-case food control directed against *Salmonella* and *Campylobacter*. The case-by-case control is anchored in Article 14 in the Food Law and is a tool for assessing the risk in individual cases, making it possible to identify and withdraw batches that pose an increased risk to human health, because of high concentrations of *Campylobacter* or specific antimicrobial resistance profiles. It was emphasised that the case-by-

case control does not cover all batches of Danish and imported meat, as it is based on random sampling.

Interventions before slaughter

Interventions before slaughter may be divided in two categories:

- Interventions aimed at preventing flocks from being infected by *Campylobacter*
- Interventions aimed at reducing the concentration of *Campylobacter* in the broiler chicken gut after the flock has been infected

Interventions aiming at preventing flocks from being infected by *Campylobacter*

Hygienic measures (Biosecurity)

A high level of hygiene/biosecurity at the farm level is one of the key components of the already existing *Campylobacter* control strategies in Denmark, Sweden, Norway, and Iceland. Common biosecurity measures to prevent *Campylobacter* from entering the broiler house include ante-rooms with physical barriers separating the dirty area (where one enters the ante-room from the outside) from the clean area (for clothes and footwear used inside the broiler house). Maintaining of a high level of biosecurity also requires change of footwear, clothes and wash of hands prior to entering the broiler house.

Areas around the broiler houses must to be included if a high level of hygiene is to be maintained. They should be tidy and free of vegetation, and an efficient pest control strategy is needed. It is generally recommended that a concrete or asphalt apron is established in front of the doors. This should be properly maintained to prevent cracks and holes from forming. Furthermore, it is recommended to place large pebbles along the sides of the houses to prevent dust from being whirled into the air. It is also important that the area around the houses is properly drained to prevent the forming of puddles, where *Campylobacter* may survive.

Results from a study on one of the newest approaches to increase biosecurity on the farm, utilising fly screens to prevent infection of broilers on Danish farms, were presented. The results from the project showed that by preventing ingress of flies and other insects (implemented by installing screens, etc. on the broiler houses) the percentage of positive flocks, during the peak season from June to November, could be reduced from approximately 50 to 15%. However, the equipment needs further development before it is ready for commercial use.

Age at slaughter

It is generally assumed that the risk of a flock being infected increases with age. Thus, in order to prevent flocks from being infected during the summer months, Iceland has put in place a scheme whereby flocks from producers known to carry a higher risk of *Campylobacter* are slaughtered at an earlier age (approximately 32 days). By doing this they have managed to bring down the number of positive flocks.

Thinning

Thinning is considered to increase the risk of introducing *Campylobacter* into a flock. However, results from Iceland suggest that thinning may be carried out without infecting the birds remaining in the house, if a number of hygienic precautions are taken. The area of the house where the thinning has taken place, should be left to dry properly, before the remaining birds are given access. This may be accomplished by setting up temporary separating barriers or walls.

Interventions aimed at reducing the concentration of *Campylobacter* in the broiler chicken gut after the flock has been infected

These interventions may include feed- and water-additives such as organic acids, bacterial culture used for competitive exclusion, as well as probiotics, bacteriocins and bacterial phages. At the present time there is no well-documented method for efficiently reducing the concentration of *Campylobacter* in the gut of broilers in infected flocks. However, several substances have been tested in small scale studies and some seem to have potential. Generally, the effect of the available methods on the number of *Campylobacter* is short lived. More research is needed to clarify the efficacy of the different additives, and to find out whether these additives can be used under industrial conditions. On-going research is also looking into the possibilities of vaccine development and the development of animals that are genetically resistant to *Campylobacter.* However, these interventions strategies have only been tested experimentally but may become relevant in the future.

Results of the experts' prioritisation – before slaughter

The experts' prioritisations of different intervention strategies before slaughter are shown in Table 1. Generally, it was agreed that a high level of biosecurity in and around the broiler houses is a necessary prerequisite to prevent colonization of broiler flocks, but may not always be sufficient to prevent infection. The results from the fly screen project were considered significant as they could indicate that a reduction in infection rates during the summer months could be achieved by preventing ingress of insects into broiler houses. Furthermore, it was discussed how procedures connected to thinning and catching could be improved in order to

prevent infection. Interventions aimed at reducing the number *Campylobacter* in the gut, such as vaccination, feed and water additives have either proven inefficient or need further development.

Interventions based on identification of positive flocks before slaughter

Sorting/channelling

Results from Sweden have shown that human infections originate from a small fraction of all broiler flocks and Norwegian data demonstrate that only a small fraction of the broiler farms produce the majority of positive broiler flocks. This emphasises that sorting of flocks according to *Campylobacter* status, followed by a reduction in the number of *Campylobacter* on the meat, is a good strategy for reducing the number of human infections. In Norway, all flocks are sampled four days before slaughter and the positive flocks are frozen or heat treated. In Sweden, a risk assessment model evaluating the possible effect of sorting of flocks based on the history of the producer, i.e. whether the flocks from the producer have been *Campylobacter* positive or negative, has been designed.

Interventions at slaughter

The interventions at slaughter can be split into two groups:

- Hygienic measures – interventions aimed at reducing faecal contamination during the slaughter process
- Decontamination – interventions aimed reducing the number of *Campylobacter* by means of physical or chemical decontamination

Hygienic measures

It is well known that processing of broiler carcasses is an unclean process where contamination of the meat with faecal material is unavoidable. Especially, the processes of defeathering and evisceration are critical with regard to spread of faeces and intestinal content. Compliance with Good Hygienic Practices (GHP) in the processing plant will lead to improved general hygiene and thereby to a reduction of numbers of *Campylobacter* on carcasses. However, GHP cannot completely prevent faecal contamination or contamination with *Campylobacter* if the birds are infected.

At the meeting, it was mentioned that a significant effect on the concentration of *Campylobacter* on carcasses could be obtained, if the gut content of the lower gut was removed prior to defeathering, thereby preventing gut content from spilling on to the carcasses. However, equipment for this operation is presently not available. Furthermore, it would be effective to prevent rupture of intestines during evisceration. Due to the different sizes of carcasses and variation in the position/location of the gut in the birds, this is not an easy option. However, improvement of equipment and procedures could be further investigated.

Decontamination

Because hygienic measures at slaughter are not sufficient to avoid *Campylobacter* contamination of broiler carcasses and broiler meat, several methods aimed at reducing the contamination have been investigated. Several studies have shown that the use of chemicals for decontamination may reduce the concentration of *Campylobacter* by 1-2 $\log_{10}$ units. A number of different chemicals are used for decontamination of carcasses in the USA and include acidified sodium chlorite, cetylpyridinium chloride, sodium hypochlorite (chlorine), peroxyacetic acid, trisodium phosphate, chlorine dioxide, hypochlorous acid, organic acids and ozone. However, at this time no chemicals have been approved for chemical decontamination of broiler carcasses in the EU. Furthermore, if chemicals were approved for such use, they would have to be rinsed off the carcasses and the meat would have to be labelled “chemically decontaminated”. This is not required in for example the USA and New Zealand.

Marinating meat with food ingredients such as wine vinegar, lemon juice, and soy sauce were mentioned as other methods for reducing the number of *Campylobacter* present on broiler meat. However, marinating implies that the meat is no longer fresh meat, but rather a meat preparation and should be labelled accordingly. This decontamination method is therefore only relevant for the increasing market of marinated products.

Since no chemicals have yet been approved for decontamination by EU, and the Danish broiler industry opposes chemical decontamination, physical decontamination may be a more relevant option for the Danish broiler industry. At the meeting, a number of different techniques for physical decontamination were high-lighted as possible means of intervention at slaughter; Freezing, crust-freezing, optimised washing, hot water washing, steam-treatment combined with ultrasound, or forced air chilling. Freezing is the only form of physical decontamination that results in reductions of 2 $\log_{10}$ units. Other methods also result in reductions of *Campylobacter*, but not to the same extent. These methods were not dismissed as possible efficient interventions, especially if used in combination. After slaughter, physical decontamination could include production of heat treated ready-to-eat products. Proper heat treatment of broiler meat is effective against *Campylobacter*.

Results of the experts' prioritisation – at slaughter

It was concluded that sorting of flocks according to *Campylobacter* status, followed by methods to reduce the number of *Campylobacter* would be useful for reducing the number of human infections related to broiler meat. In this context freezing was considered to be the only really practical method, reducing the number of *Campylobacter* on the meat by 2 $\log_{10}$ units. However, freezing all meat from positive flocks would limit the amount Danish meat available for fresh meat products during periods with high prevalence of *Campylobacter* and instead likely result in an increased import of fresh chilled broiler meat. From Danish historical monitoring data (Annual Reports; http://www.dfvf.dk/Default.aspx?ID=9606), there is evidence that imported broiler meat is more likely to be contaminated with *Campylobacter* than Danish broiler meat, thus creating a risk of causing an increase in the number of human cases. It was also suggested that some *Campylobacter* infected flocks could be allocated to the production of "consumer-safe" products, i.e. products that do not need to be handled directly, for example cuttings in oven-ready foil trays, or whole chickens in roasting bags, or even heat treated ready-to-eat products. Sorting of flocks for steam-ultrasound, crust freezing and other techniques were also considered to be potential interventions, even though some have not been fully developed yet and others result in only small reductions. However, methods causing as little change as possible for fresh chicken were preferred over freezing. The possibility of publicly exposing producers and companies, who produce/sell highly contaminated products was also discussed ("name and shame"). However, the effect of such public exposure was considered negligible. Logistic slaughter (slaughtering *Campylobacter* positive flocks after *Campylobacter* negative flocks) and irradiation were considered as irrelevant interventions for the Danish industry because likely negligible effect or demand for the product, respectively. The experts' prioritisations of different interventions are shown in Table 2.

Consumer education

Results of a Dutch project investigating how consumers handle broiler meat when preparing a meal, and how they receive information on kitchen hygiene, was presented. Consumers who had received varying degrees of counselling on how to prevent cross-contamination were observed while cooking. Samples were collected for microbiological testing. Consumers, who had been given information on good kitchen hygiene, as well as information that there might be dangerous bacteria in the meat, cross-contaminated their food in the same way as the consumers that had received no counselling. The group of consumers, who received counselling and were given a detailed recipe, telling them to change cutting boards etc., did

somewhat better than the other groups, i.e. their mean level of cross-contamination decreased just a little, but the risk decreased a lot. The conclusion of this study was that it is extremely hard to change the habits of the consumers towards better hygienic practices in the kitchen.

Nonetheless, the participants of the meeting recommended that initiatives to improve consumer information/education should be taken, in order to emphasize that the consumer also has a responsibility in reducing the risk of becoming infected. It was mentioned that teaching good hygienic practices should be prioritized for schools, so that children later in life may be ready to prepare food safely. Training of food handlers was also recommended.

The experts' individual prioritisation

Prior to the expert consultation in Copenhagen, the participants were asked to list the three interventions they considered the most important to implement in the broiler production to reduce the number of human *Campylobacter* infections. Directly after the meeting, the experts were asked to do this again. The results are shown in Table 3.

Before the meeting, the experts considered reduction in the concentration of *Campylobacter* on the meat by use of physical decontamination, combined with a high level of biosecurity in and around the broiler houses to be the most important interventions. This was followed by sorting of flocks for decontamination and fly control on the farms using fly screens. Just after the meeting the experts still rated biosecurity measures and fly screens as likely to be the most effective interventions. This was followed by identification of positive flocks before slaughter and scheduling for decontamination, primarily by physical decontamination. As a new area of focus, several mentioned limiting faecal contamination during scalding and defeathering, as well as improved slaughter hygiene. The reason for the slight shift in prioritisation may be explained by the awareness of the successful results on using fly screens and the fact that no decontamination methods exist, which simultaneously reduce counts of *Campylobacter* by 2 $\log_{10}$ units, are approved in the EU, accepted by consumers, and leave the meat fresh chilled after treatment.

Epilogue: The new Danish action plan 2008-2012

In December 2007, a report describing a new five-year Danish action plan for control of *Campylobacter* in broilers was handed over to the Minister for Food, Agriculture and Fisheries. The action plan was drafted by the Danish Food Administration, the National Food Institute, the

National Veterinary Institute, the Danish Meat Association, the Danish Poultry Council and the National Association of Ecology. The government approved the plan in the spring 2008. It is available in Danish at http://www.foedevarestyrelsen.dk/NR/rdonlyres/64DAC21D-F57F-4B4A-AE27-8D45AB450C54/11717/Campylobacterhandlingsplan91.pdf.

The main goal of the action plan is to reduce the number of human infections caused by *Campylobacter* in Danish and imported broiler meat. Therefore, the plan contains initiatives to further reduce 1) the prevalence of *Campylobacter* in Danish broiler flocks, 2) the number of *Campylobacter* on Danish broiler meat and 3) the risk of acquiring *Campylobacter* infections from imported broiler meat.

The background for including imported broiler meat in the action plan was that exposure calculations had estimated that consumption of imported broiler meat most likely is responsible for approximately 80% of the Danish human *Campylobacter* cases caused by broiler meat. The above mentioned estimation was carried out using the consumer module of the Danish risk assessment model, incorporating data from the national monitoring programme on numbers of *Campylobacter* in Danish and imported retail broiler meat, as well as tons of meat sold. Approximately one third of the broiler meat sold in Denmark is imported. Consequently, it was clear that an action plan directed solely at the Danish broiler production would not markedly reduce the burden of *Campylobacter*. The Authorities have no mandate to ban imported *Campylobacter* contaminated fresh broiler meat from the Danish market, however, the sale of heavily contaminated fresh meat can be limited by applying Article 14 in the Food Law, which states that meat can be rejected by a member state, if a food lot is considered a problem to human health as estimated by a scientifically based risk assessment. The control of food lots should be representative for the food sold in the member state, including food produced by the member state itself. This has lead to the case-by-case risk assessment performed in Denmark, where randomly sampled lots of Danish and imported poultry meat are analysed and assessed. However, only a small, randomly sampled, proportion of meat is tested.

The key initiatives of the action plan directed against the imported broiler meat include a continued and improved case-by-case based surveillance, as well as a request to retailers and wholesalers to enforce stricter requirements for food safety for their suppliers.

With regard to control of *Campylobacter* in the Danish broiler production, the action plan includes several initiatives. These concern live broilers, reduction methods during processing, as well as consumer education. The action plan does not include specific targets for broiler flock prevalence, amount of *Campylobacter* contaminated meat, counts of *Campylobacter* on the meat, or number of human *Campylobacter* cases. However, it does state that the goal is to continue the decrease in the occurrence of *Campylobacter* in broilers and to reduce the human

exposure to *Campylobacter* from broiler meat. However, the authorities intend to discuss inclusion of specific targets at a later stage, when research projects have improved technical solutions and documented the reductions in *Campylobacter* counts that may be obtained by these.

Before slaughter, the most promising intervention is fly-control using fly screens on the broiler houses. At least this applies under Danish conditions. In the first years of the action plan, these screens will be further developed. Later, a plan will be elaborated detailing the implementation of fly screens in the production. Additional initiatives include an industry code of practice for the lay out of new buildings and production hygiene, plus research elucidating the occurrence of *Campylobacter* in free-range and organic broilers and broiler meat to be able to decide management options for this branch of production.

With regard to the slaughter process, initiatives pointed towards including optimization of methods and logistics for channelling of positive flocks. The effectiveness of steam-ultrasound as physical decontamination method will be documented for in-line equipment and there will be looked at new reduction techniques and possibilities for optimized hygiene. Additionally, the authorities' control of the effectiveness of channelling (= surveillance of fresh chilled broiler meat at the two large Danish abattoirs) will be expanded to cover also smaller abattoirs. Freezing and probably steam-ultrasound is, so far, the only decontamination methods described in the plan, but other physical methods may be included if their effectiveness is documented.

To educate consumers, the plan is to launch consumer information campaigns concerning *Campylobacter* and kitchen hygiene. These will be distributed to consumers via supermarkets. The *Campylobacter* site on the homepage of the Food Authorities will be improved and educational material for school children will be developed.

Finally, the action plan recommends the development of a source account for *Campylobacter* to be able to identify the relative importance for human illness of *Campylobacter* in broiler meat compared to other sources.

Table 1. Experts' evaluation and prioritisation of intervention methods before slaughter.
1 = good/promising, 2 = good but needs further development/research, 3 = intermediate, 4 = poor.

	Pros	**Cons**	**Priority**
Biosecurity – Farm/farmer hygiene including Hygiene barrier, change of clothing and boots, hand hygiene (gloves) Ante-room of reasonable size Knee high barrier between dirty/clean area in ante-room Separate tools for clean/dirty area Hygiene procedures for vehicles on the farm (chick delivery, transport to slaughterhouse) Work sequence on farm – on multi-age farms – start with the youngest birds Hygiene procedures associated with thinning /catching teams Empty period (secure sufficient time to dry out)	Applicable Efficient Relatively low costs May be used by the industry for reward system (economic incentive)	Consistent compliance May be difficult May not always be sufficient	1
Biosecurity – Environment around broiler houses including No vegetation Gravel around the houses (large stones)/ concrete Good drainage Area between houses - should be kept clean Concrete apron – good condition (no cracks) Litter/manure disposal in surrounding fields	Also prevents the spread of other diseases Economic incentive	Unpredictable effect Extra costs Spread of infection Extra costs associated with disposable	1
Biosecurity – Insect control, fly screens Applicable for farms with a high level of biosecurity	Well documented effect Low maintenance Could be economical if fitted when houses are built	Screens and deterrents not commercially available for all types of houses Maybe expensive to fit for certain types of houses?	1
Waste disposal (dead birds etc.) Insect net around the disposal containers may reduce presence of flies, rats etc. around houses		Extra costs	1

	Pros	Cons	Priority
Thinning of flocks/Thin with care Take precautions to avoid biosecurity breaches Dividing houses (areas separated by barriers) Hygienic precautions for catchers including use of clean gloves and clean tools Allowing the empty part of the house to dry after the birds have been caught	May help industry to deliver different bird sizes demanded May help to make production more profitable	Probably really difficult to thin without causing serious breach of biosecurity	1
Slaughter broilers young (31-33 days) Some success demonstrated when implemented or high risk farms	Effective in Iceland	May not be economical Not always possible if specified size of birds is required by customer	1
Improvement of broiler houses	Increased biosecurity Reduced workload	May not be economical	1
Broiler drinking water/feed additives e.g. organic acids and bacterial culture (for improvement of gut-microbiology) Competitive exclusion Probiotics	 Easy to apply Easy to apply Easy to apply	 No clear indication that these work efficiently May need legal changes	3
Phage therapy/ Bacteriocins	Documented effect under experimental conditions	Reduction of *Campylobacter* may be short lived Maybe expensive Need evaluation	3
Broiler breeds able to clear *Campylobacter* (genetic resistance)		No resistant broiler breed available yet. May be difficult, lengthy and expensive to achieve if at all possible	3
Vaccination	Could be good if effective	Not on the market yet – need further research	3
Logistic slaughter (positive flocks slaughtered at the end of the day)		Limited overall effect Difficult to implement Requires pre-slaughter test	3
Water supply /quality (chlorinated, UV)	Documented effect	Economics, difficult to maintain	3
Feeding whole grain	Could be cheap	Further research needed to ascertain efficacy	3
Reduced presence of other animals on or in proximity of farm	Evidence that it is a risk factor	Difficult to change on current farms, but relevant in relation to location and design of new farms	3

Table 2. Experts' evaluation and prioritisation of intervention methods at and after slaughter. 1 = good/promising, 2 = good but needs further development/research, 3 = intermediate, 4 = poor. Criteria: efficacy, cost, acceptance (consumers), ease of application, stage of development.

Intervention method	Pros	Cons	Priority
Scheduled slaughter (positive flocks frozen)	Historical data available, proven effect	Pre-slaughter test Needs a relatively low prevalence May be expensive	1
Decontamination of (all) positive flocks only	Effective, if the decontamination is effective and if the test for detecting positive flocks before slaughter is reliable	Could be expensive May be difficult to achieve consistent efficacy (>1-2 log) Risk of creating market distortion and disadvantage for national industry - if demand for non-"decontaminated" meat exceeds that available from home-produced negative flocks – or if imported meat could sell cheaper compared treated products	1/3 (due to logistic difficulties)
Physical decontamination Steam-ultrasound	Possibly fairly effective Product still fresh No chemicals involved	Medium expensive Some new equipment	2
Physical decontamination Brief heat treatment (steam or hot water)	Maybe effective but conflicting results Possible to retain fresh product characteristics? No chemicals involved Could be suited for non-skin parts	Difficult to achieve success (i.e. reduction while still maintaining product quality)	2
Applying antibacterial substance into the vent before scald	Could be very effective (US data)	Not developed yet for commercial use Possibly expensive for processor (equipment)/difficult to put in use May need EFSA approval Should be applied in concert with removing lower gut contents (see above)	2

Intervention method	Pros	Cons	Priority
Marinating	Can be very effective Potential for selling at a good price ("value added product") Can be cheap	May only be possible to apply to a small proportion of products Only possible if a market can be created Can be difficult to do properly Risk of contamination inside the meat More research needed to assess feasibility under commercial conditions	2
Prevention of faecal leakage before and during defeathering	May be effective (CARMA)	No equipment developed	2/3
Chemical decontamination all carcasses	Efficacy is being considered by EFSA Effective in publications Efficacy depends on how it is applied (immersion, spray, contact time)	Could be expensive (cost of chemicals, effluent treatment etc.) Risk to workers in processing environment Risk of mixing wrongly Consumer acceptance	2 (or 4 if consumers will not buy it)
Physical decontamination crust freezing all carcasses	0.5 log reduction (ca.) Product still fresh No chemicals involved Could be combined with other interventions to achieve greater efficacy	Not as effective for whole carcasses as parts Cost	3 (1 if combined with other interventions)
Physical decontamination forced air chilling	0.5 log reduction (ca.) Product still fresh No chemicals involved	Cost	3 (1 if combined with other interventions)
Physical decontamination Freezing of positive flocks only	Effective (depends on proportion of positive flocks detected)	Could be expensive for producer (dependent on market) Thawing process may incur cross-contamination events Risk of market distortion (opening up to imports)	3
Scheduling carcasses from positive flocks for RTE meals etc. (i.e. cooked)	Could be useful to combine with other downstream interventions for carcasses from positive flocks	May not be a market to take all positive flocks Very difficult to get the logistics right	3
Channelling flocks for decontamination/ based on past performance	Not as expensive as channelling based on testing flocks More time to plan logistics	Not as efficient as channelling of positive flocks based on testing	3
"Name and shame" publicly exposing producers and companies, who produce/sell highly contaminated products	Transparency Demonstrated to be possible Ensures that home producers are treated fairly	Difficult to provide evidence and be seen to be fair Low effect Expensive	3

Intervention method	Pros	Cons	Priority
Consumer information/labelling Consumers warned about possible *Campylobacter* contamination	Cheap Has potential to be effective Create awareness of domestic produce versus import	Efficacy uncertain Could backfire	3/4
Logistic slaughter (to avoid contamination from positive to negative flocks by slaughtering negative flocks first)	Incentive for farmers and industry to do something	No big overall effect Not feasible Not applicable for both *Salmonella* and *Campylobacter* Expensive	4
Physical decontamination Irradiation	Very effective	Strong consumer resistance Expensive	4

Table 3. Experts' individual prioritizations on interventions to control *Campylobacter* in the broiler production

Before the consultation		
Intervention	Points	Priority
Reduction of concentration at slaughter with some kind of decontamination	13	1
Biosecurity	12	2
Physical decontamination at slaughter	9	3
Scheduling of flocks for slaughter	7	4
Insect control (e.g. fly screens)	6	5
After the consultation		
Intervention	Points	Priority
Biosecurity	14	1
Insect control (e.g. fly screens)	11	2
Scheduling of flocks for slaughter	10	3
Physical decontamination at slaughter	10	3
Prevention of faecal leakage/improvement of slaughter hygiene	8	5

Annex 1. Agenda

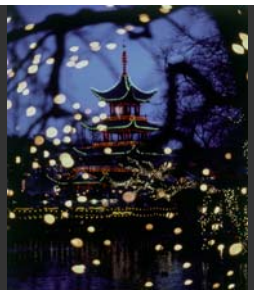
Expert Consultation on interventions to control *Campylobacter* in the broiler production

26–27th November 2007
Copenhagen

Monday 26 November 2007

10.00 – 10.30	**Registration and coffee**	
10.30 – 10.45	Welcome. Why are we here?	Henrik Wegener, DK
10.45 – 10.55	Practical information	Birgitte Borck, DK Hanne Rosenquist, DK
10.55 – 12.30	**Plenary session on interventions - Risk assessments**	Chair: Birgitte Borck
10.55 – 11.10	Investigations and the NZ Campylobacter Risk Management Strategy	Peter van der Logt, NZ
11.10 – 11.25	Investigation of intervention efficacy using the UK campylobacter risk assessment	Andy Hill, UK
11.25 – 11.35	*Short break*	
11.35 – 11.50	Quantitative risk assessment of thermophilic Campylobacter and cross-contamination during handling of raw broiler chickens evaluating strategies at the producer level to reduce human campylobacteriosis in Sweden	Mats Lindblad, SE
11.50 – 12.05	Campylobacter risk assessment in the Netherlands: conclusions about interventions	Maarten Nauta, NL
12.05 – 12.20	The effect of consumer information on the risk of campylobacteriosis	Maarten Nauta
12.20 – 12.35	Case-by-case risk assessment	Bjarke Christensen, DK
12.35 – 13.30	**Lunch, Marriott Terraneo Restaurant**	
13.30 – 15.15	**Plenary session on interventions – Primary production**	Chair: Louise Boysen, DK
13.30 – 14.00	Practical experience in broiler productions in Iceland	Sigurborg Dadadottir, IS Jarle Reiersen, IS
14.00 – 14.15	Studies on sources and interventions in UK poultry production	Viv Allen, UK
14.15 – 14.30	Reduction of Campylobacter in Swedish broilers	Ingrid Hansson, SE
14.30 – 14.45	Quantitative data on Campylobacter from commercial broiler flocks	Nico Bolder, NL
14.45 – 15.00	Risk Factors for the occurrence of Campylobacter in Danish broiler flocks	Ole Heuer/Helle Sommer, DK
15.00 – 15.15	Fly screens to control Campylobacter introduction in broiler flocks	Birthe Hald, DK
15.15 – 15.35	**Break**	

Monday 26 November 2007, continued

15.35 – 15.50	**Plenary session on interventions – Primary production - continued**	Chair: Louise Boysen, DK
15.35 – 15.50	Experience in Campylobacter interventions	Jaap Wagenaar
15.50 – 17.30	**Plenary session on interventions - Processing**	Chair: Hanne Rosenquist
15.50 – 16.05	Counting Campylobacter	Wilma Jacobs, NL
16.05 – 16.20	Positive flocks should be discovered before slaughter	Merete Hofshagen, NO
16.20 – 16.35	Transmission of Campylobacter from known Campylobacter positive flocks to the following negative flocks at slaughter	Gro Johannessen, NO
16.35 – 16.45	Factors affecting Campylobacter contamination at processing and ways of reducing it	Frieda Jørgensen, UK
16.45 – 17.00	*Short break*	
17.00 – 17.15	Campylobacter control during broiler processing – ARS research	Mark Berrang, US
17.15 – 17.30	Physical and chemical decontamination of broiler carcasses	Louise Boysen, DK
17.30 – 18.00	Conclusions of the day and introduction to group discussions	Birgitte Borck Hanne Rosenquist
18.30 – 20.00	**Dinner, Marriott Terraneo Restaurant**	
20.15 – 22.00	**Tivoli** *For those who are interested, we will meet in the hotel lobby at 20.15 hours and walk to Tivoli, which will be "dressed up" for Christmas. Remember to wear warm clothes!*	

Tuesday 27 November 2007

09.00 – 09.15	**Introduction to group discussions, prioritizing interventions, Plenum**	Hanne Rosenquist
09.15 – 10.15	**Group discussions**	
09.15 – 10.15	Group discussions on interventions in primary production, pros/cons and prioritizing best interventions (Group 1)	Facilitators: Birgitte Borck Ole Heuer
09.15 – 10.15	Group discussions on interventions at processing, pros/cons and prioritizing best interventions (Group 2)	Facilitators: Louise Boysen Hanne Rosenquist
10.15 – 10.30	**Break**	
10.30 – 12.00	**Group discussions, continued**	
10.30 – 12.00	Group discussions on interventions in primary production, pros/cons and prioritizing best interventions (Group 1)	Facilitators: Birgitte Borck Ole Heuer
10.30 – 12.00	Group discussions on interventions at processing, pros/cons and prioritizing best interventions (Group 2)	Facilitators: Louise Boysen Hanne Rosenquist
12.00 – 13.00	**Lunch, Marriott Terraneo Restaurant**	
13.00 – 15.00	**Plenary discussion on "best" interventions**	Chairs: Birgitte Borck Hanne Rosenquist
13.30 – 14.00	Interventions in primary production, prioritized list, pros/cons + Discussions	Group 1
14.00 – 14.30	Interventions at processing – prioritized list, pros/cons + Discussions	Group 2
14.30 – 14.45	Interventions at consumer level, discussions	
14.45 – 15.00	Conclusions and final remarks	Hanne Rosenquist Birgitte Borck
15.00 – 15.30	**Farewell refreshment**	

Annex 2. List of participants

First name	Last name	Organisation/Institute	E-mail
Experts			
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Annex 3. List of group participants

Group 1 Interventions before slaughter	Group 2 Interventions at and after slaughter
Ingrid Hansson	Mats Lindblad
Merete Hofshagen	Mark Berrang
Jaap Wagenaar	Maarten Nauta
Steen Nordentoft	Flemming Bager
Sigurborg Dadadottir	Helle Sommer
Jarle Reiersen	Gro Johannessen
Andy Hill	Frieda Jørgensen
Anne Wingstrand	Peter van der Logt
Viv Allen	Wilma Jacobs-Reitsma
Birthe Hald	Nico Bolder
Ole Heuer	Bjarke Christensen
Birgitte Borck	Louise Boysen
	Hanne Rosenquist

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