4. Examples of possible interventions for hazard reduction

One of the objectives of the meeting was to prepare an independent assessment and review of available scientific information on control measures. This was performed by the Experts through a review of the scientific basis of the interventions mentioned in the Codex draft Guidelines (CCFH Draft Guidelines for control of *Campylobacter* and *Salmonella* spp. in chicken meat).[2] For each step in the production chain, possible additional interventions were included.

In support of the meeting's deliberations, reference was made to either information available on the OIE Web site or to material provided in draft form for the use of the Technical Meeting. In particular the draft *Guidelines on the Detection Control and Prevention of* Salmonella *spp. in Poultry* were brought to the attention of the meeting[3]. These have already been considered by the CCFH working group in their deliberations and both the OIE and Codex documents are intended to be complementary to each other.

This chapter will follow the process flow outlined in the Codex draft Guideline document provided by the Codex working group. Comments and Expert Group opinions are given at the various steps outlined in these draft Guidelines when these are step specific, while comments and opinions covering several steps of the process (e.g. decontamination) are provided in the appendix to this report. The relevant text from the Codex draft Guidelines is provided immediately before the comments of the Experts.

The Experts wish to stress that although individual intervention methods have been reported to yield scientifically documented reduction effects when applied as the sole measure, multiple interventions are not always additive.

The Experts identified two horizontal issues with the potential to affect several steps in the processing segment of the document, the use of chlorination, and, the effectiveness of washing with water or water containing chemical processing aids.

The Experts drew on all available and documented data and evidence in support of the interventions described, with the purpose of including up-to-date relevant scientific evidence in order to supplement and expand the semi-systematic literature review that forms the basis of the draft Guidelines provided by the Codex working group. This chapter documents the review of the scientific underpinning of the Codex draft Guidelines. Where the expert meeting considered that the guidance was appropriate given the current knowledge base and scientific evidence, no further comment is given. However, in those cases where the guidance was considered to be incomplete or inappropriate given the available scientific evidence, the basis for such an opinion is provided.

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2. It must be stressed that this was a draft and therefore expected to change in the light of subsequent comments. The text on which the meeting's deliberations was based can be found at: ftp://ftp.fao.org/codex/ccfh40/fh40_06e.pdf

3. At the time of the Meeting, the primary OIE document was still technically a draft but due to go for adoption to be included in the 2009 Terrestrial Animal Health Code at the OIE General Session in the last week of May, 2009. Once adopted it would become part of Terrestrial Animal Health Code. Until that time it would be available as Annex XIII of the Report of the Terrestrial Animal Health Standards Commission. See pp. 157–162, in: http://www.oie.int/downld/SC/2009/A_TAHSC_March2009_PartA.pdf

4.1 Primary production

The Experts agreed that control measures applied at primary production are important for the control of *Salmonella* and *Campylobacter* throughout the production process and noted that they have been undertaken in a number of countries. However, due to the lack of quantification of the effect on prevalence or level of contamination on broiler carcasses, there are no validated hazard based control measures for *Salmonella* or *Campylobacter* in primary production. All of the following would be considered as GHPs by the Expert Group.

General control measures for Steps 1 to 11 (Production)

> The OIE Terrestrial Animal Health Code (March 2008) Appendix 3.4.1, Annex VI, *Hygiene and Biosecurity Procedures in Poultry Production*, provides considerable detail on control measures that apply to most production steps and should be referred to in application of these more specific Guidelines. The OIE Terrestrial Animal Health Code (March 2008) Annex V, *Guidelines on the Detection Control and Prevention of* Salmonella *spp. in Poultry*, should be referred to when applying Steps 1, 9, 10, 11 and 12. *Codex draft Guidelines*

The Experts were aware that the draft *Guidelines on the Detection Control and Prevention of* Salmonella *spp. in Poultry* has been revised and the new version had been approved by the OIE Code Commission, and was to be presented to the general meeting of OIE in May 2009.

The *Hygiene and Biosecurity Procedures in Poultry Production* draft had not yet been agreed and could be substantially revised.

Further comments are given at relevant steps of relevant interventions.

> In addition to following this general guidance, people entering the live bird production areas should not have close contact with any other birds. If such contact is unavoidable, they should not be permitted to enter live bird production areas for a specified time after the contact, and then only after the application of appropriate hygiene measures.
>
> People and vehicles who need to move in reverse of the production flow, i.e. towards Step 1, should be required to apply sufficient hygiene measures to avoid the introduction of *Campylobacter* and *Salmonella* earlier in production. People and vehicles who need to move to production areas from a feed mill or processing premises should apply appropriate hygiene measures to minimize the introduction of *Campylobacter* and *Salmonella* into production.
>
> *Codex draft Guidelines*

The Experts considered this text was appropriate given the current knowledge base and had no further additions or comments.

Step 1: Manage grandparent flocks

> Control of *Campylobacter* and *Salmonella* in grandparent flocks is achieved by the application of a combination of biosecurity and personnel hygiene measures. The particular combination of control measures adopted at a national level should be determined by the Competent Authority, in consultation with industry.
>
> Farms should be sited away from other poultry farms, livestock operations, abattoirs and identified sources of contamination. Pest control programmes, particularly to manage rodents, flies and beetles, should be in place. Wild birds should be discouraged by immediate clean-up of any feed spills, and keeping doors closed when not in use.
>
> Equipment and feeders should be designed to minimize contamination from the birds.
>
> Litter should be obtained from an uncontaminated source or be sanitized.
>
> Any equipment taken into a poultry house should be cleaned and sanitized beforehand (including equipment used for maintenance and repairs). Vehicles should be washed and sanitized at the site entrance.

> All eggs intended for incubation should be sanitized as soon as possible after lay.
>
> *Codex draft Guidelines*

In this context, it was the opinion of the Experts that there should be more details on pest control programmes, e.g. to cover domestic animals, arthropods, reptiles, flies, mites and wildlife. It was considered that the OIE guidelines covered this appropriately except for the control of arthropods.

Furthermore, it was the opinion of the Experts that microbiological sampling and testing for *Salmonella* was not adequately covered by the Codex draft Guidelines. It was considered that the OIE guidelines covered this appropriately. Also it was found that drinking water was not adequately covered in the Codex draft Guidelines, although this was found to be covered appropriately by the OIE guidelines. It was the opinion of the Experts that sanitization of eggs can have a negative effect on *Salmonella* status, chick hatchability and chick quality if the dip solution becomes contaminated or if improper temperature of the sanitizing solution is used (Williams and Dillard, 1973; Hutchison et al., 2004).

Strategies to reduce faecal contamination of eggs such as not incubating floor eggs, keeping nest boxes clean and sanitation of egg trays should be encouraged. The OIE guidelines covered this appropriately, except for floor eggs (Saeed et al., 1999). The Experts recommend that this should be considered by the CCFH working group.

When reviewing the Codex draft Guidelines, it was the opinion of the Experts that these were light on biosecurity measures. However, they found that these were appropriately covered by the OIE codes, especially for:

- cleaning and disinfection of houses and immediate surrounds or other areas of the farm that may present a reservoir for *Salmonella* or *Campylobacter*;
- staff, visitor and catcher clothing;
- vehicle parking;
- disinfection if it is necessary to enter the farm; and
- restriction on equipment shared between houses.

> For *Campylobacter:* Because of the possibility of vertical transmission, Competent Authorities may choose to apply preventative measures as a precautionary measure.
>
> *Codex draft Guidelines*

The Experts agreed that the statement regarding the possibility of vertical transmission of *Campylobacter* should be deleted, as at present there is no strong evidence that *Campylobacter* is vertically transmitted (Callicott et al., 2006). *Campylobacter* control prior to broiler farms was therefore not considered to be necessary.

> For *Salmonella:* The breeder production flock should be kept free from *Salmonella* to prevent vertical spread of infection.
>
> Incoming flocks should be screened and monitored according to a statistically-based sampling plan. Until results are available, the birds may be kept in quarantine. During rearing and production the birds should be tested according to specified sampling schemes.
>
> Where a flock is found to be *Salmonella*-positive the houses should be meticulously cleaned and disinfected before new birds are introduced. Sampling from various locations and equipment should verify that no *Salmonella* infection persists.
>
> Feed should be heat-treated or subjected to other bactericidal treatment. Breeder feed should preferably be delivered in dedicated vehicles used only for feed transport.
>
> *Codex draft Guidelines*

The Experts wanted to emphasize the value of culling positive flocks, and it was found that the OIE document covers this appropriately.

The Experts agreed that feed should be heat treated and could be subjected to other bactericidal treatment.

> For *Salmonella:* Other measures that have been evaluated in experimental or very limited commercial settings include vaccines, competitive exclusion, and feed or water additives. A Competent Authority may need to validate such measures in the national setting before advocating their use. Such measures must however not be seen as alternatives to good hygienic practices. *Codex draft Guidelines*

There are live vaccines and killed vaccines that can be used.

It was the opinion of the Experts that live *Salmonella* vaccines demonstrate non-serotype-specific and rapid protection for breeder pullets. Live vaccines also give immunity against specific serotypes. The inactivated *Salmonella* vaccines produce immunity only against specific serotypes. Combination of live and killed vaccines gives protection to the hen and maternal antibodies to the broiler. All of these are widely used commercially. Despite this, the Experts did not consider it to be a hazard control measure as the effect had not been well enough quantified regarding the impact on the resulting broilers.

The Experts stated that probiotics are defined products, whereas competitive exclusion (CE) mixtures are undefined intestinal flora. It was the opinion of the experts that the use of undefined CE products could be effective for *Salmonella* control in combination with other interventions. It decreases or prevents *Salmonella* colonization of other birds in the flock and results in a decreased concentration of *Salmonella* in caecal contents of birds that become colonized. It was accepted by the meeting that CE was in wide commercial use.

Probiotics are live microbial feed supplements that are not pathogenic for the host and able to modulate the immune response and change or stabilize microbial activities. Prebiotics are non-digestible substances with a beneficial physiological effect on the host due to the beneficial effect on the gut flora of the host. There are many publications on pre- and probiotics. Currently, there was no evidence that they could be commercially developed as effective intervention agents for *Salmonella*.

There is a great variety of feed and water additives, including organic acids, plant derivatives and enzymes (e.g. xylanase). For *Salmonella* control, there are numerous feed and water additives that have been successful when used experimentally. The opinion of the Experts was that these were not currently effective commercially, with the exception of organic acids or formaldehyde in feed. The use of organic acids in water (Dibner and Buttin, 2002) and organic acids and formaldehyde in feed reduces the concentration of *Salmonella* in the water, and also reduces the risk of contamination of feed post-heat treatment (Davies and Hinton, 2000).

It was noted that the effects of organic acids in feed are not apparent until the treated feed has been consumed by the bird and wetted in the crop.

The experimental results of bacteriocin controls for *Salmonella* looked very promising, but there had been no published field trials, so the experts considered it too early to recommend it as an effective intervention in a commercial setting. Also, the experimental results for bacteriophage therapy for *Salmonella* looked very promising, but there had been no published field trials. There were commercial companies investigating this, but it was too early to recommend it as an effective intervention in a commercial setting (Atterbury et al., 2007). Research into genetic resistance to *Salmonella* colonization showed that this had some effectiveness, but it was not a viable, cost-effective option in the near future (Wigley et al., 2006).

There had been limited experimental success for *Salmonella* control using immuno-stimulators, but it was still too early to give a recommendation as to whether this could be used as an effective intervention in a commercial setting.

The Experts furthermore stated that antimicrobials do decrease *Salmonella* concentration both in the gut and systemically, but that it would not always completely eliminate contamination. They should not be used as a *Salmonella* control measure in breeders except for salvaging valuable genetic lines, due to the risk of development of resistant *Salmonella* strains. In such cases, it should be followed by a CE product to restore the micro flora (Goren, 1993; Reynolds, 1997).

Negative air ionization had been demonstrated in research to be effective in reducing the level of *Salmonella* in the air in breeder houses, but it had not yet been applied successfully in a commercial setting.

There were many commercially available treatments to acidify the litter. Research had shown that short-term reduction in bacterial populations could be achieved. It appeared to have a limited long-term effect. The experts were not aware of any current commercial use for *Salmonella* control.

Step 2: Transport eggs to hatchery

For *Salmonella:* Egg trolleys should be cleaned and sanitized before use. They should be stored in an enclosed storage area.

Vehicles used for transporting eggs should preferably be dedicated for that purpose. The driver should, on arrival, wear protective clothing, use the boot dips provided and should not enter any livestock buildings.

Eggs from each flock should be packed into separate trays and should be identifiable. Egg trays should be labelled with the appropriate flock code and date.

Only eggs from *Salmonella*-negative flocks should be sent for incubation. When this is not feasible eggs from *Salmonella*-positive flocks should be transported well separated from eggs from negative flocks. *Codex draft Guidelines*

The Experts were in agreement with the appropriateness of the above guidance; however they noted that although it is common practice to use foot dips they are not always effective, especially in the presence of organic matter. This organic matter can result in inactivation of the disinfectant and subsequent boots can become contaminated with *Salmonella*. It might be better to suggest a change of footwear when entering the house (Amass et al., 2000).

Step 3: Parent hatchery

For *Salmonella*: The control measures as described at Step 1 also apply at this Step where relevant to a hatchery.

Each setter or hatcher should only contain eggs from one flock.

If possible, only eggs from *Salmonella*-negative flocks should be incubated as it has been scientifically demonstrated that only one *Salmonella*-contaminated egg can contaminate all eggs and newly hatched chicks within a hatching cabinet.

Where the use of eggs from flocks that are known to be contaminated is unavoidable, they should be kept separate and hatched separately from eggs from other flocks. Trace-back of infection to the contaminated breeding flocks should be performed and control measures should be reviewed.

Sampling programmes for detection of *Salmonella*, including testing dead chicks, chicken fluff, meconium and shells, should be in place. *Codex draft Guidelines*

The Experts suggested revising the text so that the types of samples listed were shown as options rather than inclusive, this meaning that at least one of the listed options should be used to monitor for *Salmonella* from the hatchery.

UV irradiation of hatching eggs has been very effective for *Salmonella* control under experimental conditions as a way to sterilize the surface of the egg. There is no commercial application as yet, probably due to staff safety issues and the negative effect on plastics.

Air sanitation in hatchers using ozone, hydrogen peroxide and phenol is effective experimentally against *Salmonella,* but commercial use is limited due to other practical concerns. Formaldehyde is still commonly used as long as staff precautions are taken.

Step 4: Transport day-old chicks to parent farm

For *Salmonella*: Personnel should follow the same hygiene routine as for collection of hatching eggs. Transport of day-old chicks should be in vehicles or containers preferably used only for that purpose. Chicks should be traceable to a hatchery. The driver should not enter any livestock buildings.

Codex draft Guidelines

Step 5: Manage parent flocks

For Salmonella: The control measures described at Step 1 apply at this Step.

Codex draft Guidelines

Step 6: Transport eggs to hatchery

For *Salmonella:* The control measures described at Step 2 apply at this Step.

Codex draft Guidelines

Step 7: Hatchery

For *Salmonella:* The control measures described at Step 3 apply at this Step.

Codex draft Guidelines

The Experts considered that the guidance provided is Steps 4 – 7 was appropriate given the current knowledge base, and had no further additions or comments.

Step 8: Transport day-old chicks to grower sheds

For *Salmonella:* The control measures described at Step 4 apply at this Step.

Codex draft Guidelines

While the Experts were in agreement that the guidance provided was appropriate they also highlighted the need to address traceability from breeder farms to hatchery.

Step 9: Manage chickens

The control measures described at Step 1, where relevant to growing farms, apply at this Step.

Unusually high levels of mortality or morbidity should be investigated.

Stand down periods for personnel are advisable during which there is no contact with birds of any type. Personnel protective clothing should be under the control of the company.

Any equipment that must be taken into a shed should be cleaned and sanitized beforehand (this includes equipment used for repairs and maintenance).

> Pest control programmes should be used outside sheds and inside the annex as necessary. Specific pests such as flies and litter beetles should be controlled to the highest level practicable. Where practicable, fly-screens may be useful in reducing the prevalence of *Campylobacter* or *Salmonella* contamination in flocks. Doors should be kept closed.
>
> Sheds should be single purpose - single species operations, and ideally an all-in all-out single-age-group principle should be adopted. Where several flocks are maintained on one farm, the individual flocks should be managed as separate epidemiological units.
>
> Where there is a detection of pathogen-positive flocks, control measures applied at processing should be considered, e.g. heat treatment or freezing of chicken meat derived from positive flocks to reduce the concentration of *Salmonella* and/or *Campylobacter.*
>
> For *Salmonella:* Feed and water additives have been used (alone or in combination with competitive exclusion) in experimental or very limited commercial settings to reduce colonization of the chickens. A Competent Authority may need to validate such measures in the national setting before advocating their use. *Codex draft Guidelines*

While agreeing on the appropriateness of the above guidance, the Experts noted that mortality during the first two weeks could be indicative of *Salmonella* infection from the breeder farms. Furthermore, the Experts were concerned at the possible effect of litter moisture on *Salmonella* (Eriksson et al., 2001) but considered this to be appropriately covered under the OIE text.

It was the opinion of the Experts that the guideline was light on biosecurity measures. However, they found that biosecurity was appropriately covered by the OIE codes, especially for:

- cleaning and disinfection of houses, their immediate surrounds and other areas of the farm that might present a reservoir for *Salmonella* or *Campylobacter*;
- staff, visitor and catchers' clothing;
- vehicle parking, and disinfection if necessary to enter farm; and
- restriction on equipment shared between houses.

> For *Salmonella*: Competitive exclusion treatments may reduce *Salmonella* flock prevalence by up to 70–85% or more. *Codex draft Guidelines*

While the Experts were in agreement with the intent of the above guidance on the utility of competitive exclusion, it was considered that it would benefit from greater clarity in terms of the efficacy of such a treatment and suggested a more appropriate statement would be "Competitive exclusion may reduce the prevalence of *Salmonella*-positive flocks and / or levels of intestinal colonisation, but the extent of any reduction can vary". Furthermore it was advised that CE be administered after antimicrobials are used for treatment of other diseases, to restore the normal gut flora (Smith and Tucker, 1975).

In addition to the GHP measures mentioned above, the meeting considered other potential interventions for implementation during broiler growing in terms of their potential practical utility in reducing *Campylobacter* and *Salmonella*. The outcome of these deliberations is documented below.

Several potential *Campylobacter* vaccines had been tested but the results were poorly reproducible. Obviously, new approaches were needed to develop effective vaccines. The opinion of the Experts was that it would take many years before a commercial vaccine would be available. There were live vaccines that could be used to control *Salmonella* in broilers, but these had not proven to be effective commercially.

Experimental studies on CE for control of *Campylobacter* showed contradictory results: some of them claimed effectiveness while others did not. Furthermore, the Experts raised the concern that there might be an under-reporting of studies showing no effect. Currently there was little evidence that CE would work against *Campylobacter*, and to the current knowledge of the Experts there was no expectation that products used against *Campylobacter* would be developed in the near future.

Organic acids appeared to be a promising feed or water additive for control of *Campylobacter*. However, large-scale field trials had yet to be performed to assess effectiveness on-farm. Other substances (e.g. monocaprin and caprylic acid, some enzymes and egg yolk powder) did not give reproducible results. The Experts concluded that the effect of these required field trials.

For *Salmonella* control, there were numerous feed and water additives that had been successful when used experimentally. At the time of writing these were not used commercially, with the exception of organic acids in pre-slaughter drinking water, and organic acids or formaldehyde in feed. The organic acids in pre-slaughter drinking water have been shown experimentally to decrease *Salmonella* concentration in crop and caeca, which may result in lower contamination on the carcass. The use of organic acids or formaldehyde in feed reduces the concentration of *Salmonella* in the feed and reduces the risk of post-heat-treatment contamination (Dibner and Buttin, 2002).

Bacteriocins are substances produced by bacteria, having anti-bacterial activity against specific other bacterial species. One research group reported promising results using these peptides against *Campylobacter* (Stern et al., 1995). There is an Intellectual Property dimension to these findings (i.e. patents). To the meeting's knowledge, only experimental data had been published. The studies to date looked very promising, but on-farm trials were needed to investigate efficacy and reproducibility under commercial conditions.

Experimental results for *Salmonella* control looked very promising, but on-farm studies had yet to be published, so it was too early to recommend it as an effective intervention in a commercial setting.

Bacteriophages are viruses able to kill specific bacterial species. Experimental studies from different research groups have shown the effectiveness on *Campylobacter* and *Salmonella*. Due to their short-term effect, the application would be limited to a small time window just before slaughter. There is only proof of principle, and on-farm studies had not yet been performed. Practical application might be hampered by lack of broad-host phages, resistance and environmental contamination issues. Phage therapy was promising, but development and application of a commercial product would need much extensive research (Atterbury et al., 2007)

There had been limited experimental success for control of *Campylobacter* or *Salmonella* using immunostimulators, but it was too early to recommend it as an effective intervention in a commercial setting.

There was no role for the use of antimicrobials in the control of *Campylobacter*. First, because of the issue of the threat of increasing antimicrobial resistance and hence the need for restricted use, and, second, because of the impossibility of practical application with regard to residues (when treatment is close to slaughter) and re-infection when the withdrawal period is respected.

The opinion of the Experts was that antimicrobials decrease *Salmonella* concentration in the gut and systemically, but would not always completely eliminate contamination. It should not be used as a *Salmonella* control measure in broilers.

Housing conditions and biosecurity are a form of prevention, controlling the introduction of infectious agents by use of hygiene measures, for example. Increasing biosecurity has definitively a role in the prevention of *Campylobacter* colonization of broilers. However, quantifying the effect is difficult and most probably dependent on regional and seasonal differences. In northern European countries (e.g. Denmark, Iceland) there is a strong suggestion that improvement of biosecurity resulted in a reduction of *Campylobacter* prevalence. However, control groups are lacking. The effect of specific measures such as fly-screens has been reported from Denmark, and is very promising. The effect of this approach in other geographical areas (e.g. other climates or ventilation systems) should be confirmed.

In the meeting's opinion, biosecurity had a (major) role to play in the reduction of the prevalence of *Campylobacter* and *Salmonella*, but quantitative prediction of the effect was difficult to ascertain.

Although various litter treatments had been used in experimental trials, in the case of *Campylobacter* there appeared to be no reduction of microbial load on the final product. The conclusion of the Experts was that there was insufficient evidence that this approach would be effective.

There are many commercially available treatments to acidify the litter. Research has shown that short-term reduction in bacterial populations can be achieved. It appears to have a limited long-term effect. The Experts were not aware of any commercial use for *Salmonella* control.

Step 10: Depopulate (full or partial)

> Full depopulation should be carried out where possible. Where this is not practicable and partial depopulation is practised, particular attention should be paid to strict biosecurity and general hygiene. This includes the prior cleaning of equipment such as transport vehicles and their tyres, forklifts, pallets/modules, catcher's boots, and transport crates. It is preferable that sheds being partially depopulated are scheduled for catching prior to those being fully depopulated on the same day. This may assist in minimizing contamination of remaining birds. Catching crews should adopt good biosecurity practices and facilities should be provided to enable them to do so.
>
> When feed withdrawal is practised, water additives such as lactic acid that may lower post-harvest crop contamination may be considered. *Codex draft Guidelines*

The Experts were in agreement with the appropriateness of the above guidance.

An agreed microbiological testing regime followed by scheduled slaughter (with positive flocks being processed separately or after negative flocks to reduce cross-contamination) or sent for further treatment post-slaughter will significantly reduce the microbial load and/or the prevalence on the carcass. Sampling should be carried out as close to slaughter as possible, taking into account the time for results to be available. This can only be done for *Campylobacter* if the flock prevalence is sufficiently low (EFSA, 2009).

Step 11: Transport to slaughterhouse

> Stress to live birds increases shedding of *Salmonella* and *Campylobacter* and should be minimized during transport by:
>
> - Giving each bird sufficient space to rest and stand up without restriction.
> - Protecting birds from undue fluctuations in temperature, humidity or air pressure.
> - Sheltering birds from extremes of weather.
>
> All live bird transport vehicles, crates, modules and associated equipment should:
>
> - Be designed, constructed and maintained to allow effective cleaning.

- Be effectively washed and sanitized, away from processing and bird holding areas so as to minimize cross-contamination, and be visibly clean.

- Be dried if practical and achievable before use in the case of crates and modules.

Codex draft Guidelines

While agreeing with the appropriateness of the above guidance, the Experts suggested that air velocity may be a more fitting term to use than air pressure.

4.2 Processing

4.2.1 Handling of crates and pre-scalding

Information on flocks presented for slaughter should be provided in a timely manner to enable optimal slaughter and processing procedures. Supplier statements or supplier guarantees covering information on flock health, e.g. relating to the use of veterinary drugs or ante-mortem inspection results, should be required upon receipt of flocks and any other materials received by the slaughterhouse.

Stress to birds should be minimized, e.g. by dim lighting, minimal handling and avoiding delays in processing. Information on flocks presented for slaughter should be provided in a timely manner to enable optimal slaughter and processing procedures

For *Salmonella:* If flocks are known positive for *Salmonella*, they should be presented for slaughter in a manner that minimizes cross-contamination to known negative flocks, e.g. by slaughtering them at the end of the day, or all on one day and preferably the last day(s) of the week. *Codex draft Guidelines*

While agreeing with the intent and to a large extent the appropriateness of the above guidance, the Experts considered the section on supplier statements or guarantees might not be necessary.

Furthermore, emphasis is put on the importance of scheduling based on information on feed withdrawal period, due to its impact on the level of carcass contamination during slaughter. Thus slaughtering flocks 8 to 12 hours after feed withdrawal will reduce likelihood of contamination of carcasses by faecal material and\or ingesta. Flock information should include details on feed withdrawal period for appropriate scheduling purposes (Northcutt, Savage and Vest, 1997; Wabeck, 1972, 1992; Warriss et al., 2004).

Step 13: Ante-mortem inspection

Moribund, unhealthy or otherwise unsuitable poultry should not be processed.

Where numbers of birds that are dead on arrival, moribund, unhealthy or otherwise unsuitable for processing exceed expected levels, the processor should notify the relevant responsible person, e.g. the farmer, veterinarian, catcher or transportation company, so that appropriate preventative and/or corrective action can be taken. *Codex draft Guidelines*

The Experts considered that the guidance provided was appropriate given the current knowledge base, and had no further additions or comments.

Step 14: Slaughter

Where practicable, known positive flocks may be diverted for specific processing and/or treatment according to national food safety policies.

Measures should be taken to minimize bird stress at hanging, e.g. use of blue light, breast comforter, suitable line speed.

Bleeding should be substantially completed before scalding in order to prevent inhalation of scald water and to reduce the amount of blood entering the scalder. *Codex draft Guidelines*

While agreeing with the appropriateness of the above guidance, the Experts highlighted that minimizing stress at hanging applied only to live hanging-on operations, and did not cover, for example, controlled atmosphere stunning/killing.

Step 15: Dress

So as to minimize contamination[4] of carcasses, control measures can include:

– Washing at key process steps to minimize attachment of *Campylobacter* and *Salmonella* to carcasses.[5]

– Trimming, to minimize visible contamination.

– Other approved chemical[6] and physical methods.

These methods can be applied alone or in combination at different process steps during processing.

Where re-hang of carcasses is necessary, it is preferable that this is done mechanically so as to reduce cross-contamination.

All birds which drop on the floor should be condemned, or reprocessed under specific conditions as determined by the Competent Authority. Any dropped products should trigger corrective actions as appropriate. *Codex draft Guidelines*

Washing at key process steps will reduce contamination by *Campylobacter* and *Salmonella*, but the Experts disagreed that this applied specifically to attachment. Trimming, washing or other measures applied to minimize visible contamination with faecal materials or ingesta on carcasses should be initiated by inspection, be it visual or automated inspection, which is becoming more common practice in industry.

4.2.2 Scalding, de-feathering and evisceration

Contamination during scalding can be minimized by:

– the use of counter-current flow;

– addition of as much fresh water as possible;

– having the scald temperature as high as possible to minimize levels of *Campylobacter* and Salmonella; and

– use of approved[7] chemicals, e.g. pH regulators.

Other factors that should be taken into account when designing process control systems that minimize contamination during scalding include:

– degree of agitation;

– use of multi-staged tanks;

– pre-scald brush and wash systems;

– raising the temperature of scald tanks to 70°C at breaks;

– tanks being emptied and cleaned at end of a processing period; and

– hygiene measures applied to re-used/recycled water. *Codex draft Guidelines*

4. Decontamination of carcasses will probably reduce, but not eliminate *Salmonella* and *Campylobacter* bacteria on broiler carcasses and broiler meat.
5. Washing with water alone may achieve a decrease in *Campylobacter* and *Salmonella* but has little effect on cells attached to the carcass surface. Further, the extent of the decrease may depend on the efficacy of previous washes.
6. Chemical decontaminants should be approved by the Competent Authority.
7. Processing aids should be approved by the Competent Authority.

Addition of as much fresh water as possible is a vague statement, and also counteracts water conservation measures by industry. It was suggested that the process should instead be specified as: *High flow rates of water with adequate agitation*. Raising the temperature of scald tanks at breaks is a sound measure, but various temperatures are applied in the industry according to plant, company and region. So the specific recommendation of 70°C is too rigorous, but could be used as an example. It should be clear that the purpose is to raise water temperature high enough for a long enough time to kill *Salmonella* and *Campylobacter* in the scalders.

Cross-contamination at de-feathering can be minimized by:
– guarantee of appropriate fasting of birds prior to slaughter;
– prevention of feather build-up on equipment;
– continuous rinsing of equipment and carcasses;
– regular adjustment and maintenance of equipment;
– particular attention to cleaning moving parts; and
– regular replacement of plucker fingers. *Codex draft Guidelines*

While agreeing with the appropriateness of the above guidance the Experts noted that the first bullet was already covered under Step 12 *Receipt at slaughterhouse*. Furthermore the importance of appropriate feed withdrawal time for impact on carcass contamination should be stressed.

4.2.3 Head pulling

Head pulling should be carried out in such a manner that leakage from the crop is prevented. Heads should be pulled downwards to reduce contamination due to crop rupture. *Codex draft Guidelines*

4.2.4 Evisceration

Rupture of the viscera and spread of faeces can be minimized by:
– limiting size variation in batches so that birds of similar size are processed together; and
– careful adjustment and regular maintenance of machinery. *Codex draft Guidelines*

The Experts considered that the guidance provided on head pulling and eviceration was appropriate given the current knowledge base, and had no further additions or comments

4.2.5 Crop removal

Where possible, crops should be extracted in a manner that is likely to reduce/limit carcass contamination. *Codex draft Guidelines*

The Experts found that there was no scientific evidence supporting the statement that specific methods for the removal of the crop would reduce carcass contamination.

4.2.6 Decontamination (washing)

Washing/rinsing with abundant potable water may be sufficient to reduce cross-contamination with *Campylobacter* and *Salmonella.* *Codex draft Guidelines*

The Experts questioned the use of the word *sufficient*, considering that there was not an established level for cross-contamination reduction. It was suggested that "*may assist in reducing*" might be more appropriate. Also, the group suggested the word *contamination* to replace *cross-contamination*. In addition, it was the opinion of the group that this was a GHP measure rather than a specific control measure.

> Chlorination of water used for carcass washing, e.g. 25 ppm, has been shown to reduce *Campylobacter* levels on skin by 0.5 $\log_{10}$ cfu/g. *Codex draft Guidelines*

The Experts questioned whether the reported reduction is due to presence of chlorine in the wash water. The draft report of the *FAO/WHO Expert Consultation on the benefits and risks of the use of chlorine-containing disinfectants in food production and food processing (*See Appendix) noted that the removal of pathogenic bacteria from poultry carcasses during physical washing procedures on an industrial scale is predominantly a feature of the physical action of the water rather than the use of hypochlorite in the water.[8]"

> Dipping of carcasses in solutions containing processing aids, e.g. 10% solution of trisodium phosphate (TSP) at pH 12 for 15 seconds, has been shown to reduce *Campylobacter* levels on skin by up to 1.7 $\log_{10}$ cfu/g. *Codex draft Guidelines*

It was the opinion of the Experts that references to the use of TSP should be removed from the document, considering that TSP was rarely used in commercial poultry processing. Some arguments include the negative environmental impacts of phosphates and the counteracting effect of the alkaline compound on the effectiveness of chlorine in chillers, e.g. chlorine performs better in pH lower than 7 (Smart, 2009).

> For *Salmonella*: Multiple-sequential washing steps have been shown to reduce the Salmonella incidence on broiler carcasses by 40 to 90%, the proportion depending on number and nature of washing interventions. *Codex draft Guidelines*

It was the opinion of the Experts that the quoted 40 to 90% was overly optimistic. However, between 4 to 8% reductions were reported in the same document for each individual washer. In two other studies, Lillard (1989, 1990) (discussed in the Appendix) showed that reductions from sequential washing steps are not additive, since limited effects of sequential washings were obtained.

The experts recommended that the Codex working group refer to reductions at individual steps when redrafting the document.

> On-line reprocessing of contaminated carcasses using TSP can significantly reduce the presence of *Salmonella*, with some reports of almost 100% of carcasses being test negative. *Codex draft Guidelines*

It was the opinion of the Experts that references to the use of TSP should be removed from the document, considering that TSP was rarely used in commercial poultry processing.

Step 16: Inside/outside body wash

It was the view of the experts that On-line reprocessing should be dealt with as a subset of washing.

> The inside and outside of all carcasses should be thoroughly washed, using pressure sufficient to remove visible contamination. Appropriate equipment should be used to ensure direct water contact with the carcass. *Codex draft Guidelines*

The Experts were in agreement with the appropriateness of the above guidance but noted that in commercial practice, the physical force needed to remove visible contaminants may be aided by the use of brushing apparatus installed in line with the inside/outside body wash (IOBW).

8. The report of the Expert meeting on the benefits and risks of the use of chlorine-containing disinfectants in food production and food processing is being finalized and minor wording changes may occur during technical editing.

> For *Campylobacter*: Washing systems. Using water alone has been shown to reduce levels of *Campylobacter* by up to 0.5 $\log_{10}$ cfu/ml of whole carcass rinse sample.[1)] *Codex draft Guidelines*

This statement is incorrect according to the reference cited as it includes 3 sequential washings with 25 ppm chlorinated water.

> Use of an inside/outside wash followed by an on-line spray system incorporating a processing aid, e.g. acidified sodium chlorite (ASC) and citric acid[9], has been shown to reduce *Campylobacter* in the whole carcass rinse sample by 1.7 $\log_{10}$ cfu/ml.
>
> [1)] Washing systems using TSP or ASC may further reduce average *Campylobacter* levels by 1.0 $\log_{10}$ cfu/ml of whole carcass rinse sample. *Codex draft Guidelines*

As noted previously it was the opinion of the expert meeting that references to the use of TSP should be removed from the document, considering that TSP was rarely used in commercial poultry processing. Further, it was suggested to review the second sentence as footnote [1)] was incorrectly placed according to the literature provided. The sentence belongs to the previous section.

The Experts found that the reference to 1.7 $\log_{10}$ reduction is not correct, and this statement should be reviewed by the Codex working group.

> For *Salmonella:* Use of an inside/outside wash, including processing aids as desired has been shown to reduce *Salmonella*-positive carcases by up to 60%. *Codex draft Guidelines*

The Experts suggested revising the statement to include conditions of application and specific agents to support it.

> Inside/outside washing using a spray application of 20–50 ppm chlorinated water may reduce the prevalence of *Salmonella*-positive broiler carcasses by 20%. A second inside/outside washing following immediately upon the first may result in a further 25% reduction. *Codex draft Guidelines*

In the opinion of the Experts a new section should be added to include practices known as On-line reprocessing (OLR) to replace the above paragraph.

To clarify the OLR process: it occurs that in certain areas of the world an additional washing step has been added following the Inside/Outside Body Wash (IOBW). This has been designated as "On-line reprocessing" and, where permitted by National Authorities, this may be used in lieu of trimming or washing off-line as a remediation for faecal or ingesta contamination. The concept was described by Blankenship et al. (1993). Kemp et al. (2001) demonstrated a better level of microbial control than that provided by Off-line reprocessing when using ASC in OLR.

Hazard-specific control for *Salmonella*: Unpublished data were presented to and accepted by the Expert Group that validated the use of ASC (750 ppm, pH ~2.5, spray application) in an OLR application. In plant trials, reductions in *Salmonella* prevalence from 48% to zero and 56% to zero were achieved (Bernard and Natrajan, pers. comm.). Another unpublished data submission indicated 18.4% reductions of *Salmonella* prevalence by the use of ASC spray washes at 700–900 ppm, pH ~2.5 (Sanchez-Plata, pers. comm.).

Step 17: Postmortem inspection

> Line speeds should be appropriate for effective post mortem inspection of carcasses for visible contamination, organoleptic defects and relevant gross pathology.
>
> *Codex draft Guidelines*

9. Reported specifications are: 15-second on-line spray system incorporating ASC at 1100 ppm and citric acid at 9000 ppm giving a pH of 2.5 at 14–18ºC.

The Experts were in agreement with the appropriateness of the above and had no further additions or comments.

4.2.7 Chilling

> Poultry meat should be chilled as quickly as possible to limit the growth of microorganisms on the carcass.[10] Chemicals that may be added to the chiller water should be approved by the Competent Authority and include, among others: *Codex draft Guidelines*

The Experts suggested that the footnote at this stage needs to be deleted because conditions of application affect the performance of chlorination. Without specifying the conditions of use, the reference is incomplete.

> – Chlorine
>
> – Chlorine dioxide and other chlorine derivatives (in the form of sodium-hypochlorite, calcium hypochlorite tablets or chlorine gas or electrolytically generated hypochlorous acid) – TSP
>
> – Organic acids (e.g. lactic acid). *Codex draft Guidelines*

The Experts suggested revision of the list of actual organic acids, to include citric acid, which is more frequently used commercially. See previous comments about TSP used in commercial settings.

4.2.7.1 Air Chilling

> Prior to air chilling, carcasses may be sprayed or dipped, e.g. chlorinated water, lactic acid or TSP, to assist cooling.
>
> During air chilling, carcasses may be sprayed with chlorinated water, lactic acid or TSP to assist cooling and reduce the level of contamination. Spraying cabinets should be installed in downflow chilling tunnels. *Codex draft Guidelines*

The Experts recommended the deletion of the two above paragraphs as there was no evidence to indicate that the use of water sprays, with or without chemicals, had a beneficial effect, and could be in fact detrimental. Added water sprays are likely to retain enough moisture during the storage to allow for survival of *Campylobacter* and withstand the drying process of the chiller (Mead et al., 2000; Allen et al., 2000a, b, 2007).

The Experts did recognize that the process of air chilling, in the reduction of the carcass temperature, would minimize the likely growth of *Salmonella* if present. The meeting asked the CCFH working group to consider the findings of the Joint FAO/WHO Expert meeting on the benefits and risks of the use of chlorine-containing disinfectants in food production and food processing (FAO/WHO, 2008)

4.2.7.2 Immersion Chilling

> Water (including recirculated water) should be potable and the chilling system may comprise one or more tanks. Chilled water can be used or ice may be added to it. Water flow should be counter-current and may be agitated to assist cooling.
>
> Immersion chilling of carcasses should incorporate:
>
> – total available chlorine maintained at 50–70 ppm, and available free chlorine maintained at 0.4–5.0 ppm; and
>
> – pH maintained at 6.0–6.5.

10. The time necessary to eliminate *Salmonella* or *Campylobacter* in the chiller water increases with decreasing free available chlorine, e.g. it takes 120 minutes to eliminate both organisms at 10 ppm but only 6 minutes at 50 ppm total available chlorine.

> Following chilling, any excess water should be allowed to drain away from the carcasses to minimize cross-contamination of carcasses at subsequent steps in the processing chain.
>
> *Codex draft Guidelines*

The Experts disagreed that chlorine should always be used with immersion chilling. Where necessary for control of *Salmonella* and *Campylobacter,* processing aids (e.g. chlorine compounds, acidulants and other approved agents) may be considered.

It was the opinion of the Experts that the GHP as written was too prescriptive and parameters should be validated in the particular circumstances (See Appendix).

> For *Campylobacter*: Air chilling may significantly reduce numbers of *Campylobacter* depending on chilling rate and humidity.[11] *Codex draft Guidelines*

Forced air chilling (Blast chilling) can be a hazard control measure for *Campylobacter* due to the drying out of the surface. The Experts recommended that this paragraph be moved to a new, hazard-based control section within air chilling.

> For *Salmonella:* Immersion chilling using water with antimicrobial agents may decrease the prevalence of *Salmonella*-contaminated carcasses by up to 50%. *Codex draft Guidelines*

The subgroup did not find substantiation for the stated reduction and suggested removing "*by up to 50%*" from the statement.

The Experts spent much time discussing the role of processing aids in reducing the levels of contamination with *Salmonella* and *Campylobacter* on broilers during the immersion chilling operation. To support the discussion, the draft report of the Joint FAO/WHO Expert meeting on the benefits and risks of the use of chlorine-containing disinfectants in food production and food processing (FAO/WHO, 2008) were used in addition to other relevant references and personal comments.

The Experts did not reach agreement on the necessity for use of processing aids for control of *Salmonella* and *Campylobacter* on broilers during the chilling process.

Points were brought forward in support of the use of chlorine or other derivatives as inactivating agents in the chiller, but questions remained as to whether the noted effects were the result of the chlorine or the physical removal of contaminants by washing.

There was general agreement among the experts that the addition of chlorine at a level sufficient to maintain a residual in the water would inactivate pathogens washed off during the chilling process, preventing re-attachment and cross-contamination.

The point of controversy remains whether the use of chlorine in the chill tank does or does not act as a decontaminating agent by acting directly on the surface of contaminated carcasses. The same applies to application of processing aids during what has been referred to earlier as OLR.

> For *Campylobacter* and *Salmonella*: A pre-chill 15-second spray or 5- to 8-second immersion dip in acidified ASC has been shown to reduce *Campylobacter* and *Salmonella* on poultry carcasses by greater than 2 $\log_{10}$ cfu per ml of whole carcass rinse sample. Reductions of 2.6 $\log_{10}$ cfu per ml of whole carcass rinse sample can be achieved if the spray or dip is preceded by a freshwater wash.
>
> *Codex draft Guidelines*

This statement describes a processing step related to the previous section; there is no chilling done at this stage and it should be considered in the IOBW or OLR section.

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11. *Campylobacter* spp. are relatively sensitive to drying and low humidity and die as a result of desiccation of the carcass surface.

> Use of an 8 to 12% solution of TSP in pre- or post-chiller baths has been shown to reduce *Campylobacter* and *Salmonella* by 1 to 2 $\log_{10}$ cfu per ml of whole carcass rinse sample.
>
> *Codex draft Guidelines*

As noted previously it was the opinion of the expert meeting that references to the use of TSP should be removed from the document, considering that TSP was rarely used in commercial poultry processing.

> For *Campylobacter*: Immersing whole carcasses in ASC immediately after the chiller has been shown to reduce *Campylobacter* by 2.6 $\log_{10}$ cfu/ml of whole carcass rinse sample.[12] In other commercial applications, ASC applied by dipping carcasses after exiting a screw chiller has been shown to reduce the prevalence of contaminated carcasses by up to 80%.
>
> *Codex draft Guidelines*

These interventions should be considered as Post-Chill applications. The Codex working group should consider placing this as a separate section in the revised document.

In addition, the Experts asked the Codex working group to go back to the original references, as the citations in terms of reported Log reduction for *Campylobacter* were incorrect.

> For *Salmonella*: Use of chlorine dioxide in chiller water at a level of 5 ppm (0.5–1.0 free residual chlorine dioxide) may reduce *Salmonella* on broiler carcasses by 2 $\log_{10}$ cfu per ml of whole carcass rinse sample. *Codex draft Guidelines*

The Experts noted that there was no such thing as free residual chlorine dioxide; it should be free residual chlorine.

The following hazard-specific control measure should go into the post-chill section.

Unpublished data were presented to and accepted by the Expert Group that the use of ASC (750 ppm, pH ~2.5, immersion dip, post-chill application) in a plant trial gave a reduction in *Salmonella* prevalence from 16% to zero (Bernard and Natrajan, pers. comm.). Another unpublished data submission indicated 15–25% reduction in *Salmonella* prevalence by the use of a chlorine dioxide generating system applied as a dip at 5 ppm post-chill (Sanchez-Plata, pers. comm.).

> Chilled carcasses should be held in temperature controlled environments and processed as soon as possible, or with the addition of ice to minimize the growth of *Campylobacter* and *Salmonella*.
>
> *Codex draft Guidelines*

The Experts suggested that the reference to *Campylobacter* should be removed, as *Campylobacter* will not grow below 32°C (ICMSF, 1996).

The Experts considered that the addition of the following hazard-based control section for *Campylobacter* was necessary as a consequence of recent published information:

"For *Campylobacter*: Crust freezing using continuous CO_2 belt freezing of portions, skinless breast fillets, provided a reduction in *Campylobacter* of 0.42 Log (Boysen and Rosenquist, 2009). The effect of crust freezing of whole birds on reducing *Campylobacter* is supported by work carried out by Corry et al. (2003)."

Step 20: Pack

> Chilled carcasses should be held in temperature-controlled environments and processed as soon as possible, or with the addition of ice to minimize the growth of *Campylobacter* and *Salmonella*.

12. Reported specifications are: Immersion of whole carcasses in 600 to 800 ppm ASC at pH 2.5 to 2.7 for 15 seconds.

> Care should be taken when packaging to minimize external contamination of the pack. Leakproof packaging, where possible, should be leakproof. *Codex draft Guidelines*

The Experts suggested that the reference to *Campylobacter* should be removed as *Campylobacter* will not grow below 32°C (ICMSF 1996).

The Experts agreed that minimizing cross-contamination was an important aspect of packaging and could be achieved in several ways, e.g. leakproof packaging or absorbent pads. However, it was not advocated that leakproof packaging should be applied in all situations.

> For *Campylobacter*: If modified atmosphere packs are used, the atmosphere chosen should not enhance the survival of *Campylobacter.* *Codex draft Guidelines*

A high oxygen concentration (70%) reduced the survival of *Campylobacter* during chilled storage by 2.0 to 2.6 Log over 8 days of storage (Boysen, Knøchel and Rosenquist, 2007). The Experts recommended that the Codex working group consider this as a hazard-based control option. As this is being drafted, the Codex working group should take care that new measures do not create other hazards.

> For *Salmonella:* Products should at all times be stored at temperatures preventing growth of *Salmonella*.[13] *Codex draft Guidelines*

While scientifically correct, the Experts considered that this text should be moved to Section 9.11 of the Codex draft Guidelines as it refers to storage.

> For *Campylobacter* and *Salmonella*: Gamma rays or electron beams[14] applied to warm, chilled, or frozen carcasses has been shown to be effective at eliminating *Campylobacter* and *Salmonella*. Where permitted, irradiation levels should be approved by the Competent Authority. Radiation at doses of 3–5 kGy for frozen poultry and 1.5–2.5 kGy for chilled poultry has been shown to eliminate *Salmonella* and *Campylobacter.* *Codex draft Guidelines*

The Experts noted that a range of doses had been reported, and should therefore be validated in the particular situation.

Step 21: Chill/freeze

> Measures based on GHP are provided in the Code of Hygienic Practice for Meat, CAC/RCP 58-2005 [CAC, 2005] with further guidance in the International Code of Practice for the Processing and Handling of Quick Frozen Foods, CAC/RCP 8-1976, Rev. 2-2008 [CAC, 2008].
>
> *Codex draft Guidelines*

It was considered that such general statements should be included in the introduction to the draft document.

> For *Campylobacter*: Freezing of naturally contaminated carcasses followed by 31 days of storage at -20°C has been shown to reduce *Campylobacter* by 0.65 to 2.87 $\log_{10}$ cfu/g.
>
> *Codex draft Guidelines*

The Experts agreed with the note that freezing will reduce *Campylobacter* contamination (Rosenquist et al., 2006).

4.2.8 Storage

> Measures based on GHP are provided in the Code of Hygienic Practice for Meat, CAC/RCP 58-2005 [CAC, 2005] with further guidance in the International Code of Practice for the Processing and Handling of Quick Frozen Foods, CAC/RCP 8-1976, Rev. 2-2008 [CAC, 2008].

13. Packaging in modified atmosphere does not prevent growth of *Salmonella* if temperature abuse occurs.
14. Refer to Codex Standard 106-1983, Rev. 1-2003, General Standard for Irradiated Foods.

Codex draft Guidelines

It was considered that this was a general statement rather than specific guidance and should go in the introduction to the draft document.

For *Salmonella*: Products should at all times be stored at temperatures preventing growth of *Salmonella*.[15] *Codex draft Guidelines*

The Experts agreed with the appropriateness of the guidance that products should be stored below temperatures allowing growth of *Salmonella*. The Experts could not agree on the need for application of this criterion *at all times*. Growth is time and temperature dependent; there are disagreements as to the exact temperatures to prevent growth, as well as questions regarding the impact of short periods at higher temperatures (Ingham et al., 2004).

4.3 Distribution, handling and preparation

4.3.1 Temperature control

The requirements for temperature control during transportation and storage of the product are covered adequately by the Code of Hygienic Practice for Meat, CAC/RCP 58-2005 (CAC, 2005).

In relation to cooking of raw chicken, the NACMCF (2007) review specifies that cooking to a minimum internal temperature of 74°C will give a 7 $\log_{10}$ reduction in *Salmonella* and a 50 $\log_{10}$ reduction in *Campylobacter*. However, the data available to the Experts for both pathogens was based on extrapolation of data from lower temperatures and different kinds of meat. Nevertheless, it should be noted that ready-to-eat meat and poultry products sampled at manufacturing plants for regulatory compliance during 2001 and 2002 yielded only 23 samples positive for salmonellae in over 14 000 tested (Dreyfuss et al., 2007) using the mentioned temperature of 74°C.

For *Campylobacter*, there is published data on fried chicken breast (Bergsma et al., 2007) and unpublished data on *Campylobacter* and *Salmonella* on chicken breast fillets showing unusual heat resistance. It was the opinion of the Experts that further work was needed to verify this. Commercial cooking practices following the guidelines in the document have a proven performance history of minimizing the risk of *Salmonella* and *Campylobacter*. However, studies on home cooking practices were not definitive at that time.

Factors that could affect heat resistance, such as: presence of chemical additives; size and conformation of the product; type of cooking process; water activity; fat content; and pH, must be taken into account to establish a heat regime. The variable nature of survival curves is recognized in the FAO/WHO document (FAO/WHO, 2002).

4.3.2 Cross-contamination

The requirements for meat handling at retail, as specified in the Codex Draft guidelines Section 10.4.1.1) were acceptable. In relation to food service operators, it was recommended that hygiene measures should be aimed at minimizing cross-contamination between raw chicken and hands, contact surfaces and utensils, but should prevent contamination of other foods. Information to consumers on food safety requirements given by the CCFH Guidelines should also be channelled through relevant national media.

15.Packaging in modified atmosphere does not prevent growth of *Salmonella* if temperature abuse occurs.

4.4 Identification of data gaps

Main data gaps for primary production were:

- *Salmonella* and *Campylobacter* prevalence information was available for some countries worldwide, but many of these studies gave limited details of study design.
- Data were limited or missing from most countries in Africa, Asia, Latin America and the Caribbean.
- There were very limited data on the concentration of *Salmonella* on positive birds.
- The effect on *Salmonella* and *Campylobacter* prevalence and concentration of specific risk reduction interventions needs to be evaluated.

Main data gaps for processing were:

- Quantitative data were limited for several steps of processing.
- There was limited information on processing practices used in different countries.
- Many studies were old; more recent information on changes in prevalence and numbers would be beneficial.

Main data gaps for cooking and handling were:

- Quantitative data regarding cooking practices and handling are needed.
- Systematic investigations are needed of the prevalence or level of contamination in this step.