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DISCUSSION PAPER ON RISK MANAGEMENT STRATEGIES FOR *SALMONELLA* SPP. IN POULTRY

Prepared by Sweden with the assistance of Australia, Brazil, Canada, China, Czech Republic, Denmark, France, Germany, Netherlands, New Zealand, Thailand, USA, the European Commission and ALA

BACKGROUND

At its 34th session in Bangkok, the Codex Committee on Food Hygiene was informed about the outcome of the FAO/WHO expert consultations on risk assessment on *Listeria* and *Salmonella*. It was noted that there was a need to develop a discussion paper on Risk Management Strategies for *Salmonella* spp. in broilers based upon the risk assessment document (FAO Food and Nutrition Paper 72). The committee agreed that a drafting group, led by Sweden should develop a discussion paper to be considered at its next Session. The drafting group met in Uppsala, Sweden, the 25-26th of February 2002.

At the 35th session in Orlando the Codex Committee on Food Hygiene discussed the document and it was decided that the drafting group should elaborate the document and specifically:

- refine and prioritize possible interventions throughout the food chain with potential for risk reduction, with a view of formulating questions to risk assessors to be delt with in modelling risk;
- encourage inputs from experts on aspects throughout the food chain;
- risk management/risk assessment should be further developed.

A circular letter (CL 2003/25 FH) has been sent to Codex Contact Points asking for input relevant to the points stated above and a literature study has been performed. The results of these activities have been incorporated in the document.

An alternative suggestion from the USA in the form of a risk profile is presented in Annex I.

In order to facilitate an understanding of the document it is recommended that it should be red in conjunction with relevant sections of the Joint FAO/WHO Expert Consultation on Risk Assessment of Microbiological Hazards in Foods (FAO Food and Nutrition Paper 72, Rome 2000). The document is available from:

http://www.who.int/fsf/mbriskassess/Report_of%20_July2000_Consultation.pdf

1. INTRODUCTION

At the 33rd session of the CCFH, the preliminary report of the Joint FAO/WHO Expert Consultation was discussed and a number of risk management questions to be addressed by the FAO/WHO expert consultations were identified. Amongst these were questions concerning on-farm interventions. These could not however, be evaluated due to lack of representative data.

The drafting group, considering the result of the risk assessment, the information received in response to the circular letter and the literature study and realising the current gaps in data concerning the efficacy of various strategies, has decided to refrain from prioritising between specific strategies and instead list known interventions with their known advantages and disadvantages. The group acknowledges that a combination of risk management interventions is the best way of achieving a reduction of contaminated products on the market. The challenge is to find the optimal combination of interventions.

The choice of appropriate risk management strategies for *Salmonella* spp. in broilers falls within national competence and should be discussed in the national context. Each country can select those risk management strategies that are most appropriate to its national situation. What is, at one point of time, feasible and highly effective for one country might, at the same time, be quite unrealistic and/or ineffective for another.

It is preferable, that prior to selecting their strategies, the countries set their appropriate level of protection and the food safety objective as regards S*almonella* in broilers in order to guide the selection.

2. RISK MANAGEMENT STRATEGIES IN THE BROILER PRODUCTION CHAIN

Good agricultural practices and good hygienic practices in the whole production chain are necessary prerequisites for the successful application of specific risk management strategies. Depending on their situation, countries may initially select to target certain *Salmonella* serotypes with most public health significance.

2.1 Breeder production

It is crucial to keep the breeder production flock free from *Salmonella* because an infected flock will spread the infection to a large number of commercial flocks. The efficient control of *Salmonella* spp. in all parent flocks reduces the prevalence at the broiler production stage (SCVMPH, 2000).

General principles:

- Buildings and facilities should be designed to prevent other animals from entering.
- The interior surfaces in the buildings should be easy to clean and disinfect.
- Access to the buildings by persons should be subject to precautions.
- Feed and drinking water should be free from *Salmonella.*
  - Feed production control and feed heat treatment are essential for preventing Salmonella infections on farms (SCVMPH, 2000). Serovars found in the feedmills can often be found in the birds during rearing and/or slaughter (Corry et al., 2002). The risk for Salmonella contamination is increased when feed meal instead of pellets are given the chickens (Rose et al., 1999).
- The outdoor environment should be such that rodents and other pests are discouraged from approaching and entering the buildings.
  - Rodent control is an essential part of a *Salmonella* control programme (Davies and Wray, 1996). Beetles (Hald et al., 1998), wild birds (Craven et al., 2000) and flies (Bailey et al., 2001b) are other potential *Salmonella* sources.
- Pest control programmes should be in place.
- Hygienic zones should be established with detailed routines and hygienic instructions for employees and visitors, handling of equipment etc.

- The houses including all equipment should be cleaned and disinfected between flocks and dry-out time should be respected before new flocks are introduced.
  - The difficulties with cleaning and disinfection to remove *Salmonella* in broiler houses has been discussed by Rose et al., 2000 and by Davies and Wray, 1995. Ineffective routines even are known to aggravate the problem (Wray, 1995).
- An all in – all out strategy should be used.
- Employees must be well educated in basic hygiene and must have a good understanding of the sanitary procedures used.

Specific strategies:

- Ensuring that incoming birds (future breeders) are *Salmonella*-free. This may require quarantine and sampling newly arrived birds (faecal or blood samples, lining of the box used for delivering the chicks, dead chicks).
- Positive animals should not enter the breeding stock.
- Testing birds during rearing and production according to specific sampling schemes.
- Excluding *Salmonella*-positive flocks from the breeding chain. The flocks should preferably be sent to slaughter or to special treatment. The eggs should be destined for production of egg products where the elimination of salmonellas is guaranteed.
- Vaccines: for specific serotypes (for example *S*. Enteritidis and *S*. Typhi-murium) vaccines are available.
  - *Salmonella* live vaccines may interfere with bacteriological testing whereas vaccines with killed *Salmonella* may interfere with serological testing. The use of vaccination depends on the epidemiological situation. Vaccines have very little chance of eradicating *Salmonella* from an infected flock, but may decrease the infectious burden. The positive effects of vaccines against S, Enteritidis and S. Typhimurium have been demonstrated by, amongst others, Feberwee et al.(2000) and Clifton-Hadley et al. (2002).
- Competitive exclusion. A mixture of normal intestinal flora [from SPF birds] may be given [either as spray at the hatchery or in the transport crates or added to the drinking water to the day-old chicks].
  - Competitive exclusion has been shown to effectively reduce the risk of salmonella infection (Bailey et al., 2000; Blankenship et al., 1993; Corrier et al., 1998; Fukata et al., 1999; Hume et al., 1996; Nisbet, 2002; Palmu and Camelin, 1997; Stern et al., 2001). A cumulative beneficial effect was observed when competitive exclusion was preceeded by administering gentamicin in ovo on day 18 (Bailey and Line, 2001a).
- Use of prebiotics, probiotics or organic acids as feed supplements.
- Reduced colonization of the intestine by *Salmonella* in chickens has been demonstrated when feed has been supplemented with carbohydrate prebiotics (Fukata et al., 1999; Van Immersel et al., 2002).

  – Probiotics, mostly *Lactobacillus* species, have also been shown to reduce cecal colonization in broiler chickens (Chambers and Lu, 2002; Immersel et al., 2002). A probiotic mixture combined with Salmonella-specific antibodies gave a lower concentration of Salmonella cecal colonization (Tellez et al., 2001).

  - A substantially reduced susceptibility for *Salmonella* Enteritidis colonisation in broilers fed fermented liquid feed containing high numbers of lactic acid bacteria and an increased concentration of lactic and acetic acid (pH approx. 4) has been reported (Heres et al., 2003).

  - Addition of organic acids to feed has been shown to reduce the horizontal transmission of *Salmonella* species (Hinton and Linton, 1988; Hinton et al., 1990).

- Cleaning and disinfecting of houses before new birds are introduced. 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 in the houses should verify that no *Salmonella* contamination persists.
  - *Salmonella* contamination of the house before introducing day-old chicks has been shown to be a significant risk factor (Heyndrickx et al., 2002; Humphrey and Allen, 2002a; Rose et al., 1999).
- Due to questionable effect and the risk of resistant *Salmonella* strains the use of antibiotics[1] is not recommended, neither for prevention nor cleaning the flock of *Salmonella*.
  - Some antibiotics may prolong the carrier–state in poultry and some may increase the numbers of salmonellas being shed (Smith and Tucker, 1975,1978, 1980 cited by Humphrey et al., 1988). Several antibiotics have been reported to increase the incidence of *Salmonella* colonization (Manning et al., 1994)

2.2 Hatchery

The important role of the hatchery in the *Salmonella* infectious chain has been highlighted by several studies (Bailey et al., 1998, 2001b, 2002; Rose et al., 1999; Skov et al., 1999).

General principles:

- Buildings and facilities should be designed to prevent vermin from entering.
- The interior surfaces of the buildings should be easy to clean and disinfect.
- The equipment used must be easy to clean and disinfect and should be cleaned and disinfected between each batch.
- Hygienic instructions (e.g. protective clothing and footwear) for the personnel should be in place.
- The design of the hatchery and layout of rooms should reflect the principle of clean-dirty separation such that all activities beyond the point of transfer from the setters to the hatchers are considered dirty. Product and personnel should not be allowed to move freely from the dirty side back into the clean side.

Specific strategies:

- Purchase of eggs only from flocks tested *Salmonella*-free.
- Separate handling in time and location of eggs from *Salmonella*-infected flocks and *Salmonella*-free flocks. Special cleaning and disinfection routines should be used after hatching of eggs from *Salmonella*-infected flocks.
- Sampling programmes should include testing dead chicks, chicken fluff, meconium and shells.
- Reducing airborne dust.
  - Reducing airborne dust in experimental hatching cabinets with an electrostatic space charge system reduced the cecal concentration of *Salmonella* in broilers at 7 days of age (Mitchell et al., 2002).
- Positive batches are sent for destruction or the chickens are kept separate from *Salmonella*-free flocks further along the food-chain. Trace back of the infection to the breeding flock of origin will allow measures to prevent further infection to be taken.
- Transportation of day-old chickens should be done in clean, disinfected and dry boxes and in clean and disinfected vehicles.

2.3 Broiler production

[1] Antibiotics in this report refers to substances used or foreseen to be used for human medical or veterinary purposes

In the broiler production the same general principles apply as for breeder production.

Specific strategies:

- Meticulous cleaning and disinfection routines following a contaminated flock.
  - *Salmonella* contamination of the house when day-old chicks are introduced is a significant risk factor (Rose et al. 1999).
- Sampling to verify that no infection persists in the building and equipment before a new flock is introduced.
- Introduction of *Salmonella*-free day-old chickens.
  - *Salmonella* contamination of day-old chicks was found to be a main risk factor for *Salmonella* contamination of the flock (Rose et al., 1999).
- Competitive exclusion. (see 2.1. breeder production).
- Use of prebiotics, probiotics or organic acids as feed-supplements (see 2.1. breeder production).
- Special attention to preventing litter-beetle infestation.
- Vaccination.
  - The use of inactivated *Salmonella* vaccines in broilers would be possible. The use of live *Salmonella* vaccines would also be possible, however, their usage has to guarantee by determining the appropriate withdrawal period, that *Salmonella* vaccine organisms do not enter the food chain.
- The use of antibiotics is not recommended due to questionable effect and the risk of resistant *Salmonella* strains (see 2.1. breeder production).
- Sampling the flock before transportation to slaughter.
  - This sampling should take place as late as possible during production while ensuring that the results are available before transportation. This will allow precautionary measures at slaughter and further down the chain (logistic slaughter and channelling) to be taken. Samples can be taken from dead birds, cloacal swabs, faeces or the litter-bed. Serological analysis can also be used, but the number of serotypes that can be detected will be limited.
- Destruction of positive flocks or special slaughter and special treatment of the meat from positive flocks.
- Withholding of feed from the birds before transport to slaughter.
  - Withholding of feed is a practice widely used in order to reduce rupture of the intestines at evisceration. This practise may however be counter-productive since feed withdrawal has been shown to markedly increase the incidence of *Salmonella* in the crop (Corrier et al., 1999; Ramirez et al., 1997, Hargis et al., 2001). The crop may serve as a major source of *Salmonella* contamination in some plants (Sarlin et al., 1998).
  - Lactic acid administered in the drinking water during preslaughter feed withdrawal significantly reduced the crop contamination with *Salmonella* (Byrd et al., 2001). Incorporation of experimental chlorate product (ECP) in the drinking water during a 10-hours pretransport feed-withdrawal reduced the incidence of *Salmonella* in crop contents and the ceacal concentration of *Salmonella* (Byrd et al., 2003).
  - Addition of sodium nitrate via feed for 5 days immediately before slaughter combined with experimental chlorate product (ECP) added to the drinking water for the last two days reduced the concentration of *Salmonella* in the cecal content as well as the number of *Salmonella*-positive broilers (Jung et al., 2002).
- Treatment that will kill *Salmonella* bacteria in manure from contaminated flocks.

2.4 Transport and lairage

General principles:

- Clean, disinfected and dry crates should be used for transporting chickens.
  - Commonly used methods for washing and disinfecting crates are inefficient and washed crates are sometimes more frequently contaminated with *Salmonella* than unwashed crates (Bailey et al., 2001b; Corry et al., 2002; Humphrey and Allen , 2002b). Improved hygiene management during transport of broilers could reduce the risk of *Salmonella* contamination of poultry meat (Heyndrickx et al., 2002)
- Vehicles should be cleaned thoroughly between transporting different flocks and, when necessary, disinfected.
- People involved in collecting chickens for transportation should follow basic hygienic rules.

Special strategies:

- The use of so-called broiler harvesters should be limited to not infected flocks. If not, they should be carefully cleaned and disinfected between flocks.
- Yeast treatment.
  - Yeast treatment (10 % yeast in the feed for 60 hours prior to feed withdrawal) has been shown to reduce *Salmonella* colonization associated with broiler chickens subjected to transport stress (Line et al. 1997).

2.5 Slaughter

It is well known that poultry processing does not reduce carcass contamination with salmonellas and also that the proportion of contaminated carcass can increase during slaughter. Nevertheless differences in hygiene practises between slaughterhouses with resulting differences in carcass contamination have been demonstrated indicating that improved hygiene management could significantly reduce the risk of *Salmonella* contamination of broiler meat (Heyndrickx et al., 2002).

Cross contamination occurs especially during scalding, defeathering, head pulling, evisceration and chilling. At present no effective barriers that might control *Salmonella* during processing exist (Fries, 2002).

Good Manufacturing Practices (GMP) and Good Hygienic Practices (GHP) including good design, maintenance and cleaning of equipment, are prerequisites for the slaughtering process. Furthermore HACCP plans should be implemented.

Specific critical points in the slaughtering process:

- The water flow in tanks should be according to the counter-current principle.
- Head pulling should be carried out so that leakage from the crop is prevented.
- Evisceration should be carried out with care to prevent damage to the viscera leading to leakage of intestinal contents.
- Chilling should give a temperature of $\leq 4^{o}$ C in all parts of the carcass in less than 4 hours.
- Air chilling might be preferable to water chilling due to reduced risk for cross-contamination.

Specific strategies:

- *Salmonella* positive flocks should be slaughtered at the end of the week or at least at the end of the day.
- Special (intensified) cleaning and disinfection routines after slaughtering infected flocks.

- Channelling of the meat from infected flocks e.g. to be used for heat-treated products or to other bactericidal treatments.
- Increasing scalding temperature.
  - An increase from 50 to 60°C reduced the concentration of *Salmonella* on broiler skin (Yang et al., 2001).
- Decontamination of poultry carcasses.
  - Chemical decontamination may, according to published results, give a reduction in salmonellas of 1 – 2 ^{10}logs. Therefore decontamination should only be used as part of an overall strategy for *Salmonella* control throughout the whole production chain. Decontamination should not be used as the primary pathogen reduction measure or as a substitute for appropriate control measures at the production level or at the slaughterhouse.
  - Organic acids, tri-phosphates, chlorine, chlorine dioxide are the compounds that are usually used. According to the SCVMPH chlorine dioxide, acidified sodium chlorite and trisodium phosphate are effective against spoilage and pathogenic bacteria present on poultry carcasses in terms of reducing the pathogen load albeit not eliminating it (SCVMPH, 2003). Decontamination with irradiation or ionisation are effective, according to published results, but public resistance against these methods exists in many countries. Other methods that have been shown to reduce the microbial load on chicken carcasses are the combined use of an inside –outside bird washer and an acidified sodium chlorite spray system (Kere Kemp et al., 2001) and electrolysed oxidizing water (Fabrizio et al., 2002). Before any decontamination compound or decontamination technique is authorised for use its efficacy and safety should be fully assessed.
- Sampling programmes to assess cross-contamination and the effect of the slaughtering processes and decontamination steps on the prevalence of *Salmonella* or concentration of indicator organisms on the carcasses. Microbiological criteria can be set to guide the assessment of the results and the corrective actions to be taken.

2.6 Processing

Again GMP, GHP including good design, maintenance and cleaning of equipment are prerequisites., HACCP plans should be implemented. Practices that will prevent cross-contamination must be strictly applied.

Specific strategies:

- Sampling programmes to measure cross-contamination and changes in *Salmonella*-prevalence or concentration of indicator organisms. Microbiological criteria can be used either as guidelines in the processing or as end product criteria.
- Labelling of raw poultry products to inform the consumer on proper handling and cooking.
- Packing in controlled atmospheres.
- If contaminated flocks are slaughtered and the meat from such flocks is specially channelled, measures to prevent contamination of *Salmonella*-free meat batches should be in place. In particular, the physical separation of contaminated and not contaminated meat batches must be under control.

2.7 Distribution and retail sale

In these steps the aim is to prevent growth of *Salmonella* and to prevent the contamination of other products. Again GMP and GHP are prerequisites that should be complemented by HACCP-plans. Special attention should be paid to storage temperature, prevention of cross-contamination and the length of shelf-life.

Specific strategies:

- Physical separation of contaminated and not contaminated products as well as separation of cooked and raw products.

2.8 Catering

GMP and GHP are prerequisites when preparing and serving food. HACCP-plans should be implemented. Training personnel in food hygiene is considered to be very important. In institutional kitchens, preparing food for the diseased and the elderly people, special care must be taken to avoid cross-contamination and to ensure that the broiler products are cooked satisfactorily.

2.9 Consumption

Educating/informing the consumer about basic food hygiene and how to handle the risks with broiler products in their kitchen is considered to be effective in reducing the incidence of salmonellosis in humans. Press, radio, TV, video, cinema, information on the web, brochures, etc. may be used. This kind of information can be a part of the education given in schools. Information may be general or targeted to special sectors or groups, like susceptible groups at risk. Experience shows that a long time-perspective is necessary for this kind of education to be successful.

3. AVAILABLE INFORMATION AND MAJOR KNOWLEDGE GAPS

The risk characterization of *Salmonella* spp. in broilers (FAO Food and Nutrition Paper 72) starts at the end of slaughterhouse processing. The effects of interventions at the earlier stages in the farm-to-fork continuum are, because of lack of representative data, not presently included in the model.

In order to be able to estimate which risk management strategies that would give the best effects the data gaps need to be filled. When new data is available a risk assessment/[risk profile] can be performed hopefully leading to more precise recommendations of which risk management strategies that would be most effective in reducing the probability of illness per serving.

The main data gaps identified for the primary production module are as follows

- *Salmonella* prevalence information is available for some countries world-wide, however many of these studies give *limited details of study design*.
- Regions for which there is a lack or limited amount of prevalence data include Africa, Asia and South America.
- No information relating to *sensitivity or specificity* of tests used is presented in the studies.
- There are very limited data relating to *numbers of organisms* per positive/contaminated bird.
- The effect on *Salmonella* prevalence of specific risk reduction interventions.

The main data gaps for processing are as follows:

- There is limited public information on *processing practices* followed by different countries of the world (for example scalding or chilling methods, including addition of chemicals).
- *Quantitative data* (i.e. numbers of organisms) are limited, for several steps of processing.
- Many studies are old, *more recent information* on changes in prevalence and numbers would be beneficial.

4. CONCLUSIONS

The document on risk assessment of *Salmonella* spp. in broiler chickens contained limited information concerning the effects of various risk reduction options. However, the outcome of the document is that the risk for *Salmonella* infection is related to the prevalence of *Salmonella* contaminated carcasses.

It was acknowledged that destruction of *Salmonella* positive flocks will influence public health outcomes, but due to lack of specific information on how this would translate to fewer infected birds or fewer *Salmonella* cells per infected bird at the completion of processing, the magnitude of risk reduction was not estimated.

It was nevertheless estimated that a reduction in the concentration of Salmonella cells on carcasses leaving the chill tank as well as a reduction in the prevalence of infected birds leaving processing would reduce the risk of illness per serving at least proportionally.

The expert group found the available data on the importance of various routes for introduction of *Salmonella* spp. into flocks, including feed, replacement birds, vectors and hygiene to be inconclusive. It was not possible therefore to evaluate the importance of on-farm routes of introduction of *Salmonella* spp.

The expert group also pointed out the need to increase the understanding of cross-contamination processes in all the different steps in the production chain.

The drafting group has identified interventions to be taken at different steps in the food-chain for broiler chicken which may reduce the risk for the consumers for *Salmonella* infections. These interventions have in experimental situations been shown to reduce the prevalence of *Salmonella* contaminated carcasses and/or the concentration of *Salmonella* on contaminated broilers. No quantitative data on the effects of these interventions on the prevalence of *Salmonella* contaminated carcasses or the concentration of *Salmonella* on contaminated broilers when implemented in ordinary full-scale broiler production have been found by the drafting group.

The drafting group realises that this lack of data makes it difficult to evaluate the effects on the prevalence of infected broiler chickens as well as the concentration of *Salmonella* cells per infected bird that can be expected from various risk management interventions.

5. RECOMMENDATION

The drafting group recommends that the Committee:

- Request that the drafting group established at the 34th session of CCFH determine whether existing Codex codes of hygienic practice provide sufficient information for the hygienic control of *Salmonella* spp. in broiler chickens.
- If the guidance provided in current Codex codes is insufficient, the drafting group will recommend good production and manufacturing practices for the production, slaughter and processing of broiler chickens. Such new work may involve amending existing Codex texts or the development of new microbiological risk management guidance.

In order to assure that such recommendations are based on the best available knowledge the drafting group further recommends the Committee to:

- Encourage all Codex member countries to supply to the drafting group relevant scientific data related to risk management strategies reported in this document for control of *Salmonella* spp. in broiler chickens.
- Request that the drafting group in the light of new scientific data assess the likely impact on prevalence in broiler chickens and/or risk to human health of the various risk management strategies reported in this document.

REFERENCES

Bailey, J.S., Cason, J. A. and Cox, N.A. 1998. Effect of *Salmonella* in young chicks on competitive exclusion treatment. *Poultry Science*, 77, 394-399.

Bailey, J.S., Stern, N.J. and Cox, N.A. 2000. Commercial field trial evaluation of mucosal starter culture to reduce *Salmonella* incidence in processed broiler carcasses. *Journal of Food Protection*, 63, 867-870.

Bailey, J.S. and Line, E. 2001a. In ovo gentamicin and mucosal starter culture to control *Salmonella* in broiler production. *Journal of Applied Poultry Research,* 10: 376-379.

Bailey, J.S., Stern, N.J., Fedorka-Cray, P., Craven, S.E. Cox, N.A., Cosby, D. E., Ladely, S. and Musgrove, M.T. 2001b. Sources and movement of *Salmonella* through integrated poultry operations: A multistate epidemiological investigation. *Journal of Food Production*, 64, 1690-1697.

Bailey, J. S., Cox, N.A., Craven, S.E. and Cosby, D.E. 2002. Serotype tracking of *Salmonella* through integrated broiler chicken operations. *Journal of Food Protection*, 65,742-745.

Blankenship, L.C., Bailey, J.S., Cox, N.A., Stern, N.J., Brewer, R. and Williams, O. 1993. Two-step mucosal competitive exclusion flora treatment to diminish salmonellae in commercial broiler chickens. *Poultry Science*, 72, 1667-1672.

Byrd, J.A., Hargis,B.M., Caldwell, J.D., Bailey, R.H., Herron, K.L., McReynolds, J.L., Brewer, R.L., Anderson, R.C., Bischoff, K.M., Callaway, T.R. and Kubena, L.F. 2001. Effect of lactic acid administration in the drinking water during preslaughter feed withdrawal on *Salmonella* and *Campylobacter* contamination of broilers. *Poultry Science*, 80, 278-283.

Byrd, J.A., Anderson, R.C., Callaway, T.R., Moore, R. W., Knape, K.D., Kubena, L.F., Ziprin, R.L. and Nisbet, D.J. 2003. Effect of experimental chlorate product administration in the drinking water on *Salmonella* Typhimurium contamination of broilers. *Poultry Science*, 82, 1403-1406.

Chambers, J.R. and Lu, X. 2002. Probiotics and maternal vaccination for *Salmonella* control in broiler chickens. *Journal of Applied Poultry Research*, 11, 320-327.

Clifton-Hadley, F.A., Breslin, M., Venables, L.M., Sprigings, K.A., Cooles, S.W., Houghton, S. and Woodward, M.J. 2002. A laboratory study of an inactivated bivalent iron restricted *Salmonella enterica* serovars Enteritidis and Typhimurium dual vaccine against Typhimurium challenge in chickens. *Veterinary Microbiology*, 89, 167-179.

Corrier, D.E., Nisbet, D.J., Byrd, J.A., Hargis, B.M., Keith, N.K. Peterson, M. and DeLoach, J.R. 1998. Dosage titration of a characterized competitive exclusion culture to inhibit *Salmonella* colonization in broiler chickens during growout. *Journal of Food Protection*, 61, 796-801.

Corrier, D.E., Byrd, J.A., Hargis, B.M., Hume, M.E., Bailey, R.H. and Stanker, L.H. 1999. Presence of *Salmonella* in the crop and ceca of broiler chickens before and after preslaughter feed withdrawal. *Poultry Science*, 78, 45-49.

Corry, .J.E.L., Allen, V.M., Hudson, W.R., Breslin, M.F. and Davies, R.H. 2002. Sources of *Salmonella* on broiler carcasses during transportation and processing: modes of contamination and methods of control. *Journal of Applied Microbiology*, 92,424-432.

Craven, S.E., Stern, N.J., Line, E., Bailey, J.S., Cox, N.A. and Fedorka-Cray, P. 2000. Determination of the incidence of *Salmonella* spp., *Campylobacter jejuni,* and *Clostridium perfringens* in wild birds near broiler chickens houses by sampling intestinal droppings. *Avian Diseases*, 44, 715-720.

Davies, R.H. and Wray, C. 1995. Observations on disinfection regimens used on *Salmonella enteritidis* infected poultry units. *Poultry Science*, 74, 638-647.

Fabrizio, K.A., Sharma, R.R., Demirci, A. and Cutter, C.N. 2002. Comparison of electrolyzed oxidizing water with various antimicrobial interventions to reduce *Salmonella* species on poultry. *Poultry Science*, 81, 1598-1605.

Feberwee, A., de Vries, T.S., Elbers, A.R.W. and de Jong, W.A. 2000. Result of a *Salmonella* Enteritidis vaccination field trial in broiler breeder flocks in the Netherlands. *Avian Diseases*, 36, 992-999.

Fries, R. 2002. Reducing *Salmonella* transfer during industrial poultry meat production. *World´s Poultry Science Journal*, 58,527-540.

Fukata, T., Susai, K. Miyamoto, T. and Baba, E. 1999. Inhibitory effects of competitive exclusion and fructooligosaccaride , singly and in combination, on *Salmonella* colonization of Chicks. *Journal of Food Protection*, 62, 229-233.

Hald, B., Olsen, A. and Madsen, M. 1998. *Typhaea stercorea* (*Coleoptera*: *Mycetophagidae*), and carrier of *Salmonella enterica* serovar Infantis in a Danish broiler house. *Journal of Economic Entomology*, 91, 660-664.

Hargis, B.M., Caldwell, D.J. and Byrd, J.A. 2001. Microbiological pathogens: live poultry considerations. In: Sams, A.R. ed. *Poultry meat processing*. Boca Raton, CRC Press, 121-135.

Heres, L., Engel, B., van Knapen, F., de Jong, M.C.M., Wagenaar, J.A. and Urlings, H.A.P. 2003. Fermented liquid feed reduces susceptibility of broilers for *Salmonella enteritidis*. *Poultry Science*, 82, 603-611.

Heyndrickx, M., Vandekerchove, D., Herman, L. Rollier, I., Grijspeerdt, K. and De Zutter, L. 2002. Routes for *Salmonella* contamination of poultry meat: epidemiological study from hatchery to slaughterhouse. *Epidemiology and Infection*, 129, 253-265.

Hinton, A., Corrier, D.E., Spates, G.E., Norman, J.O., Ziprin, R.L., Beier, R.C. and DeLoach, J.R. 1990. Biological control of *Salmonella typhimurium* in young chickens. *Avian Disease*, 34, 626-633.

Hinton, A. and Linton, A.H. 1988. Control of *Salmonella* infections in broiler chickens by the acid treatment of their feed. *Veterinary Record*, 123, 416-421.

Hume, M.E., Corrier, D.E., Nisbet, D.J. and DeLoach, J.R. 1996. Reduction of *Salmonella* crop and cecal colonization by a characterized competitive exclusion culture in broilers during growout. *Journal of Food Protection*, 59, 688-693.

Humphrey, T. and Allen, V. 2002a. Food Standards Agency project ZB00034: Biosecurity on the broiler farm as an anti-*Salmonella* control measure.

Humphrey, T. and Allen, V. 2002b. Food Standards Agency project ZB 00033. Poultry transport crate hygiene.

Humphrey, T.J., Mead, G.C. and Rowe, B. 1988. Poultry meat as a source oh human salmonellosis in England and Wales. *Epidemiology and Infection*, 100, 175-184.

Jung, Y.S., Anderson, R.C., Byrd, J.A., Edrington, J.A., Moore, R.W., Callaway, T.R., McReynolds, J. and Nisbet, D.J. 2003. Reduction of *Salmonella* Typhimurium in experimentally challenged broilers by nitrate adaptation and chlorate supplementation in drinking water. *Journal of Food Protection*, 66, 660-663.

Kere Kemp, G., Aldrich, M.L., Guerra, M.L. and Schneider, K. R.. 2001. Continuous online processing of fecal- and ingesta contaminated poultry carcasses using an acidified sodium chlorite antimicrobial intervention. *Journal of Food Protection*, 64, 807-812.

Line, J.E., Bailey, J.S., Cox, N.A. and Stern, N. 1997. Yeast treatment to reduce *Salmonella* and *Campylobacter* populations associated with broiler chickens subjected to transport stress. *Poultry Science,* 76, 1227-1231.

Manning, J.G., Hargis, B.M., Hinton, A., Corries, D.E., DeLoach, J.R. and Creger C.R. 1994 Effect of selected antibiotics and anticoccidials on *Salmonella enteritidis* cecal colonization and organ invasion in Leghorn chicks. *Avian Diseases*, 38, 256-261.

Mitchell, B.W., Buhr, J.R., Berrang, M.E., Bailey, J.S. and Cox, N.A. 2002. Reducing airborne pathogens, dust and *Salmonella* transmission in experimental hatching cabinets using an electrstatic space charge system. *Poultry Science*, 81,49-55.

Nisbet, D. 2002. Defined competitive exclusion cultures in the prevention of enteropathogen colonisation in poultry and swine. *Antonie Van Leeuwenhoek*, 81, 481-486.

Palmu, L. and Camelin, I. 1997. The use of competitive exclusion in broilers to reduce the level of *Salmonella* contamination on the farm and at the processing plant. *Poultry Science*, 76, 1501-1505.

Rose, N., Beaudeau, F., Drouin, P., Toux, J.Y., Rose, V. and Colin, P. 1999. Risk factors for *Salmonella enterica* subsp. *enterica* contamination in French broiler-chicken flocks at the end of the rearing period. *Preventive Veterinary Medicine*, 39, 265-277.

Rose, N., Beaudeau, F., Drouin, P., Toux, J.Y., Rose, V. and Colin,P. 2000. Risk factors for *Salmonella* persistence after cleansing and disinfection in French broiler-chicken houses. *Preventive Veterinary Medicine*, 44, 9-20.

Sarlin,L.L., Barnhart, E.T., Caldwell, D.J., Moore, R.W., Byrd, J.A., Caldwell, D.Y., Corrier, D.E., DeLoach, J.R. and Hargis, B.M. 1998. Evaluation of alternative sampling methods for *Salmonella* critical control point determination at broiler processing. *Poultry Science*, 77, 1253-1257.

Scientific committee on Veterinary Measures relating to Public Health (European Commission). 2003. The evaluation of antimicrobial treatments for poultry carcasses.

Scientific Committee on Veterinary Measures relating to Public Health (European Commission). 2000. Opinion on food-borne zoonoses.

Skov, M.N., Angen, O., Chriel, M., Olsen, J.E. and Bisgaard, M. 1999. Risk factors associated with *Salmonella enterica* serovar typhimurium in Danish broiler flocks. *Poultry Science*, 78, 848-854.

Stern, N.J., Cox, N.A., Bailey, J.S., Berrang, M. E. and Musgrove, M. T. 2001. Comparison of mucosal competitive exclusion and competitive exclusion to reduce *Salmonella* and *Campylobacter* spp. colonization in broiler chickens. *Poultry Science*, 80, 156-160.

Tellez, G., Petrone, V.M., Escorcia, M., Morishita, T.Y., Cobb, C.W. and Villasenor,L. 2001. *Journal of Food Production*, 64, 287-291.

Van Immersel, F., Cauwerts, K., Devriese, L.A., Haesebrouk, F. and Ducatelle, R. 2002. Feed additives to control *Salmonella* in poultry. *World´s Poultry Science Journal*, 58, 501-513.

Wray, C. 1995. Salmonellosis: A hundred years old and still going strong. *British Veterinary Journal*, 151, 339-341.

Yang, H., Li, Y. and Johnson, M.G. 2001. Survival and death of *Salmonella* Typhimurium and *Campylobacter jejuni* in processing water and on chicken skin during poultry scalding and chilling. *Journal of Food Production*, 64, 770-776.

ANNEX I Suggestion from the U.S.A.

DISCUSSION PAPER ON RISK MANAGEMENT STRATEGIES FOR SALMONELLA SPP. IN BROILER CHICKENS

Background

At its 34th session in Bangkok, the Codex Committee on Food Hygiene was informed about the outcome of the FAO/WHO expert consultations on risk assessment on *Listeria* and *Salmonella*. It was noted that there was a need to develop a discussion paper on Risk Management Strategies for *Salmonella* spp. in poultry based upon the risk assessment document (FAO Food and Nutrition Paper 72). The committee agreed that a drafting group, led by Sweden with the assistance of Australia, Canada, China, Czech Republic, Denmark, France, Germany, Netherlands, New Zealand, Thailand, USA and the European Commission, should develop a discussion paper to be considered at its next Session. The drafting group met in Uppsala the 25-26th of February 2002.

Scope and Rationale

At the 33rd session of the CCFH, the preliminary report of the Joint FAO/WHO Expert Consultation was discussed and a number of risk management questions to be addressed by the FAO/WHO expert consultations were identified. Amongst these were questions concerning on-farm interventions. These could not however, be evaluated by JEMRA due to lack of representative data. It was acknowledged that destruction of *Salmonella* positive flocks will influence public health outcomes, but due to the lack of specific information on how this would translate to fewer infected birds or fewer *Salmonella* cells per infected bird at the completion of processing, the magnitude of risk reduction was not estimated. It was nevertheless estimated that a reduction in the concentration of *Salmonella* cells on carcasses leaving the chill tank as well as a reduction in the prevalence of infected birds leaving processing would reduce the risk of illness per serving at least proportionally. The expert group found the available data on the importance of various routes for introduction of *Salmonella* spp. into flocks including feed, replacement birds, vectors and hygiene to be inconclusive. It was not possible therefore to evaluate the importance of on-farm routes of introduction of *Salmonella* spp. The expert group also pointed out the need to increase the understanding of cross-contamination processes in all the different steps in the production chain.

The drafting group, considering the result of the risk assessment and realising the current gaps in data concerning the efficacy of various strategies, decided to refrain from prioritising between specific strategies and instead listed known options with their known advantages and disadvantages. The group acknowledges that a combination of risk management options is the best way of achieving a reduction of contaminated products on the market. The challenge is to find the optimal combination of options.

The choice of appropriate risk management strategies for *Salmonella* spp. in broilers falls within national competence and should be discussed in the national context. Each country can select those risk management strategies that are most appropriate to its national situation. What is, at one point in time, feasible and highly effective for one country might, at the same time, be quite unrealistic and/or ineffective for another.

It is preferable, that prior to selecting their strategies, the countries set their appropriate level of protection and the food safety objective as regards S*almonella* in broilers in order to guide the selection.

Since information about the effects of different risk management strategies is rarely available, all parties are invited and encouraged to forward such information.

Risk Profile for *Salmonella* spp. in Broiler Chickens

Note: portions of the text have been copied [*with permission*] from the JEMRA Risk Assessment of *Salmonella* Enteritidis in eggs and *Salmonella* spp. in broiler chickens.

1. Pathogen food commodity combination of concern

1.1 Pathogen of concern
Salmonella spp. (non-typhoidal)

1.2 Description of the food or food product and/or condition of its use with which problems (foodborne illness, trade restrictions) due to this pathogen have been associated.
Broiler chicken is the commodity of interest

2. Description of the public health problem

2.1 Description of the pathogen including key attributes that are the focus of its public health impact (e.g. virulence characteristics, thermal resistance, antimicrobial resistance).
Salmonella are gram-negative, rod shaped, facultative bacteria in the family Enterobacteriacea. For the purpose of this report all *Salmonella* are considered to belong to the genus enterica, following the nomenclature suggested by WHO (1988, WHO).

- Virulence Characteristics
  Non-typhoid *Salmonellae* possessing certain adaptive characteristics are more likely to produce foodborne disease. First, they must be acid tolerant to survive the pH of the stomach. They must also be able to attach themselves to and invade the intestinal epithelia and Peyer's patches (D'Aoust, 1997). Bacterial virulence factors include those that promote adhesion to host cells in the intestines: specific fimbriae, chromosome-coded bacterial surface adhesins, hemagglutinins, and epithelial cell induction of bacterial polypeptides which can promote colonization and adhesion.

Resistance of *Salmonellae* to lytic action of complement varies with the length of the O side chains of lipopolysaccharide (LPS) molecules (D'Aoust, 1991). Smooth varieties are more resistant than rough types. O side chains of the LPS have also been shown to affect invasiveness and enterotoxin production (Murray, 1986).

Siderophores, which chelate iron, are necessary for the accumulation of sufficient environmental iron to allow growth of *Salmonellae*. Siderophores include hydroxamate, phenolate, and catechol types. Porins are hydrophobic bacterial cell proteins which enhance the virulence of *Salmonella* by repression of macrophage and polymorphonuclear-dependent phagocytosis. *Salmonella* porins may however have a limited importance in pathogenicity. Chromosomal determinants include specific virulence genes whose potential for action is tightly controlled by regulatory genes. Expression of the genes is determined by the environment and invasion occurs by the two-component regulatory system PhoPQ which enables survival of *Salmonellae* within the hostile environment of phagocytes (Slauch et al., 1997).

Virulence plasmids in the range of 50-100 kb have been associated with the ability to spread after colonization, invasion of the intestine, ability to grow in the spleen, and a general suppression of the host immune response (Slauch et al., 1997). The presence of virulence plasmids in *Salmonellae* is limited. Chiu *et al* (1999) studied virulence plasmids in 436 clinical human samples in Taiwan: 287 isolates were from faeces, 122 from blood and the remaining were isolated from other sites. Sixty-six percent of the non-faecal isolates compared with 40% of the faecal isolates contained a

virulence plasmid. All the isolates (n=50) of the three highly invasive serotypes - *S*. Enteritidis, *S. dublin* and *S. choleraesuis* contained virulence plasmids. Virulence plasmids have also been confirmed in *S. typhimurium, S. gallinarum-pullorum* and *S. abortusovis*, but are notably absent in *S. typhi*, which is host-adapted and highly infectious.

Other factors that affect the ability of the organism to cause disease include the presence of cytotoxins and diarrhoeagenic enterotoxins. The enterotoxin is released into the lumen of the intestine and results in the loss of intestinal fluids (D'Aoust, 1991).

Antimicrobial resistance of the organism may also affect the severity of the outcome of infection. The effects of underlying illnesses often complicate evaluation of the added clinical impact of resistant *Salmonella*. In a study referring to the United States and the years 1989-90, after accounting for prior antimicrobial exposure and underlying illness, patients with resistant *Salmonella* were more likely to be hospitalized (Lee et al., 1994). A longer duration of illness and hospitalization was also noted for resistant infections.

- Serotypes

  More than 2,200 *Salmonella* serotypes have been identified based on the Kauffman-White scheme (e.g. Enteritidis).

- Thermal resistance

  "*Salmonella* are sensitive to heat, and, generally speaking, the organisms are killed at temperatures of 70°C or above. Because of this characteristic, ordinary cooking is sufficient to destroy *Salmonella* cells if applied for times sufficiently long enough to reach this temperature throughout the food being cooked." (Guthrie, 1992)

- Susceptibility to antimicrobial agents

Antimicrobial resistance may affect the severity of the outcome of illness from *Salmonella*. In a study referring to the years 1989-1990, patients with resistant *Salmonella* were more likely to be hospitalized, after accounting for prior antimicrobial exposure and underlying illness (Lee et al., 1994). A longer duration of illness and hospitalization was also noted for resistant infections. The National Antimicrobial Susceptibility Monitoring System provides susceptibility information on *Salmonella* from human and animal populations. A summary of susceptibility testing of several *Salmonella* serotypes to 17 antimicrobial agents can be found in Table 1 (Headrick and Cray, 2001). As part of the 1999 study, 8,508 *Salmonella* isolates of animal origin were tested against 17 antimicrobial drugs. The results in Table 1 clearly indicate that many *Salmonella* serotypes are resistant to some of the antibiotics commonly used in human and animal health, and as growth promoters in the animal production industry.

Antimicrobial	Percent Sensitive
Amikacin	>99.9
Amoxicillin/clavulanic acid	88.4
Ampicillin	81.9
Apramycin	98.9
Ceftiofur	96
Ceftriaxone	97.7
Cephalothin	92.3
Chloramphenicol	90.1
Ciprofloxacin	100
Gentamicin	90.8
Kanamycin	87.7
Nalidixic Acid	98.8
Streptomycin	69
Sulfamethoxazole	71.1
Tetracycline	64.8
Trimethoprim/sulfa	96.6

2.2 Characteristics of the disease, including:

- Susceptible populations

Epidemiologic information indicates that susceptibility is highest in infants, elderly people and immuno-compromised hosts. However, the dose response relationship developed by the Expert Group could not distinguish between normal and susceptible (children less that five years of age) populations.

- Annual incidence rate in humans including, if possible, any differences between age and sex and any differences according to regional and seasonal variations

A common observation is that the age of patients with *Salmonella* infections is distributed according to a bimodal distribution with peaks in children and elderly.
However, it should be pointed out that association with age may be spurious. Children and the elderly with diarrhoea may be expected to be more frequently cultured than other age groups (Banatvala et al., 1999). Moreover, age association may reflect behavioural characteristics. For instance, eating snow, sand, or soil - a behaviour more likely in children - was found to be associated with infection by *S. typhimurium* O:4-12 (Kapperud et al., 1998a).

In terms of number of isolates, men seem to be generally more affected than women. A male-to-female ratio of 1.1 has been reported on various occasions (Blaser and Feldman, 1981;Le Bacq et al., 1994;Wong et al., 1994). The significance of such a finding does not appear to have been addressed. Several factors, such as proportion of the two genders as well as different age distributions for males and females within a country or hospital catchment area, may play an important role. In the evaluation of a single study, it should be pointed out that the occurrence of other factors, e.g. use of antacids or pregnancy, relates to one gender more often or exclusively and gender may thus have the effect of a confounder.

The potential role of race and ethnicity has seldom been considered. As mentioned above, an association with black race and Hispanic origin was reported for resistant *Salmonella* infections (Lee et al., 1994;Riley et al., 1984). In the former case, the association was explained by differences in the distribution of infecting serovars among ethnic groups, which in turn depended on varying food preferences or methods of food preparation.

An association between altered nutritional status and acute gastroenteritis has been shown in AIDS patients (Tacconelli et al., 1998). Apart from this report, no direct reference to the role of nutritional status was found in the literature.

Isolation rates of several Salmonella serovars among groups of different socioeconomic extraction have been compared on the basis of the Townsend score, an index for deprivation (Banatvala et al., 1999). While isolation rates for S. typhimurium were not related to the Townsend score, highest isolation rates of S. Enteritidis were observed in more prosperous areas. A theory was advanced that proposes populations living in such areas more frequently ingested vehicles harboring S. Enteritidis.

CDC data (1996) demonstrates that the foodborne disease outbreaks caused by *Salmonella* in the United States occur more frequently in the summer as compared to the winter months (Figure 1). Temperature may be a major factor impacting the survival and proliferation of *Salmonella Enteritidis* (SE), i.e., warm temperatures provide an environment in which *Salmonella* can grow during the processes of production, transport, and storage (Guthrie, 1992; Latimer, 1999).

- Outcome of exposure

Infection usually causes a self-limiting enterocolitis with symptoms resolving within 5 days.

- Severity of clinical manifestation

  Salmonellosis generally manifests as a self-limiting episode of enterocolitis, with symptoms resolving within 5 days. Incubation period is generally 8-72 hours; watery diarrhoea and abdominal pain are common symptoms. Susceptibility is highest in infants, elderly people and immunocompromised hosts. However, the dose response relationship developed by the Expert Group could not distinguish between normal and susceptible (children less that five years of age) populations.. Occasionally, systemic infections can occur, particularly with *Salmonella dublin* and *Salmonella cholerasuis* infections which exhibit a predilection toward septicaemia (D'Aoust, 1997).

- Case fatality rate

  The average case-fatality rate among cases reported to FoodNet, 1996-1997 in the U.S. was 0.0078 (Mead, 1999).

- Nature and frequency of long-term complications

  Salmonella has been implicated as a triggering organism for reactive arthritis (ReA) and Reiter's syndrome. Reactive arthritis is characterized by the development of synovitis (joint swelling and tenderness) within a few weeks after the occurrence of gastroenteritic symptoms. Reiter's syndrome is defined as the occurrence of arthritis with one or more extra-articular symptoms typical of the disease such as conjunctivitis, iritis, urethritis, and balanitis. The prognosis for ReA is usually favourable with symptoms lasting for <1 year in most persons, although 5 to 18% may have symptoms that last more than 1 year and 15 to 48% may experience multiple episodes of arthritis.

- Availability and nature of treatment

  For uncomplicated enterocolitis in an otherwise healthy adult, no specific treatment other than rehydration and electolyte replacement is usually perscribed. Antibiotics may result in production of resistant strains of bacteria. (Guthrie, 1992)

- Percentage of annual cases attributable to foodborne transmission

  Although occasionally associated with exposure to pets, reptiles, and contaminated water, salmonellosis is primarily a foodborne disease. Mead et al. (1999) estimated that 95% of non-typhoidal salmonellosis cases are foodborne in the US.

2.3 Characteristics of the foodborne transmission.

- Epidemiology and etiology of foodborne transmission, including characteristics of the food or its use and handling that influence foodborne transmission of the pathogen

  Salmonellosis is one of the most frequently reported foodborne diseases worldwide. Poultry and poultry products are common food vehicles of the disease in many countries. Each year, approximately 40,000 *Salmonella* infections are culture-confirmed, serotyped, and reported to the United States Centers for Disease Control and Prevention (CDC), which estimates an annual rate of 1.4 million cases, 16,430 hospitalizations, and 582 deaths in the United States alone (Mead *et al*., 1999). Of total cases, 96% are estimated to be caused by foods. International data summarized by Thorns (2000) provides estimated incidences of salmonellosis per 100,000 people for the year 1997: 14 in the USA, 38 in Australia, and 73 in Japan. In the Europe Union, the estimates range from 16 cases per 100,000 (The Netherlands) to 120 cases per 100,000 in parts of Germany.

- Foods implicated

  A wide range of foods has been implicated in foodborne illness due to *Salmonella* with poultry as a principal source (Bryan and Doyle, 1995; Humphrey, 2000).
  The food vehicles implicated in outbreaks from *Salmonella* spp., in the United States between 1993 and 1997 include eggs (17), beef (14), ice cream (11), chicken (6), and pork (4), (Table 1) (CDC, 2000).

- Frequency and characteristics of foodborne outbreaks

  In the US between 1993 and 1997, there were a total of 655 foodborne disease outbreaks involving 43,821 illnesses, attributable to bacterial pathogens. A total of 357 (54.5%) outbreaks involving 32,610 (74.4%) illnesses were due to *Salmonella* spp. (Mead, 1999).

- Frequency and characteristics of foodborne sporadic cases

- Epidemiological data from outbreak investigations

2.3 Economic impact or burden of the disease

- Medical, hospital costs

  Costs of foodborne salmonellosis have been calculated for the United States population, and are estimated as high as US $2,329 million annually (in 1998) for medical care and lost productivity (Frenzen *et al*., 1999).

- Working days lost due to illness, etc

  Normally 1-3 days are lost due to illness.

- Damage to broiler markets

  Damage to international trade does occur due to disputes between countries over the presence of *Salmonella* spp. in broilers.

- Food Production, processing, distribution and consumption

- Characteristics of the commodity (commodities) that are involved and that may impact on risk management.

- Description of the farm to table continuum including factors which may impact the microbiological safety of the commodity (i.e., primary production, processing, transport, storage, consumer handling practices).

RISK MANAGEMENT STRATEGIES IN THE BROILER PRODUCTION CHAIN[1]

3 Other risk profile elements

- Regional differences in the incidence of foodborne illness due to the pathogen

  Regional differences in the incidence of salmonellosis occur within and among countries. International data summarized by Thorns (2000) provides estimated incidences of salmonellosis per 100,000 people for the year 1997: 14 in the USA, 38 in Australia, and 73 in Japan. In the

[1] The US suggestion is to include the text from section 2 in the main document here.

European Union, the estimates range from 16 cases per 100,000 (The Netherlands) to 120 cases per 100,000 in parts of Germany.

- The extent of international trade of the food commodity

- Public perceptions of the problem and the risk
  In general the public is well informed of the risk from *Salmonella* spp. on chickens. Recent large-scale outbreaks in the US and other countries reinforce the need to prevent cross-contamination in kitchens as well as to cook meat (including chicken) thoroughly.

- Potential public health and economic consequences of establishing Codex risk management guidance.

4 Risk assessment needs and questions for the risk assessors

Questions posed to the risk assessment group by the 33rd CCFH (Alinorm 01/13A)

- Estimate the risk from pathogenic *Salmonella* spp. in chicken (broilers) consequential to a range of levels in raw poultry for the general population and for various susceptible population groups (elderly, children, and immuno-compromised patients).

- Estimate the change in risk likely to occur for each of the interventions under consideration including their efficacy.
  - Reduce the prevalence of positive flocks
    - Destruction of positive breeder and chicken /(broiler)flocks
    - Vaccination of breeding flocks
    - Competitive exclusion (e.g. with *Salmonella* sofia)
  - Reduce the prevalence of positive birds at the end of slaughter and processing
    - Use of chlorine in water chilling of chicken (broilers)
    - Water chilling vs air chilling for chicken (broilers)

- Evaluate the importance of various routes for introduction of pathogenic *Salmonella* into flicks including feed, replacement birds, vectors, and hygiene.

5 Available Information and Major knowledge gaps

The main data gaps identified for the primary production module are as follows

- *Salmonella* prevalence information is available for some countries world-wide, however many of these studies give *limited details of study design*.

- Regions for which there is a lack or limited amount of prevalence data include Africa, Asia and South America.

- No information relating to *sensitivity or specificity* of tests used is presented in the studies.

- There are very limited data relating to *numbers of organisms* per positive/contaminated bird.

The main data gaps for processing are as follows

- There is limited public information on *processing practices* followed by different countries of the world (for example scalding or chilling methods, including addition of chemicals).

- *Quantitative data* (i.e. numbers of organisms) are limited, for several steps of processing.

- Many studies are old, *more recent information* on changes in prevalence and numbers would be beneficial.

Recommendation

The working group reviewed the conclusions of the risk assessment provided by JEMRA:

> The expert group found the available data on the importance of various routes for introduction of *Salmonella* spp. into flocks including feed, replacement birds, vectors and hygiene to be inconclusive. It was not possible therefore to evaluate the importance of on-farm routes of introduction of *Salmonella* spp. The expert group also pointed out the need to increase the understanding of cross-contamination processes in all the different steps in the production chain.

and therefore recommend that the Committee:

> Request that the Drafting Group established at the 34th Session of CCFH determine whether existing Codex codes of hygienic practice provide sufficient information for the hygienic control of *Salmonella* spp. in broiler chickens. If the guidance provided in current Codex codes is insufficient, the working group will recommend good production and manufacturing practices for the production, slaughter, and processing of broilers chickens. Such new work may involve amending existing Codex texts or the development of new microbiological risk management guidance.

References

Banatvala N, Cramp A, Jones IR, Feldman RA (1999) Salmonellosis in North Thames (East), UK: associated risk factors. *Epidemiology and Infection*, 122:201-207.

Blaser MJ, Feldman RA (1981) *Salmonella* bacteremia: reports to the Centers for Disease Control, 1968-1979. *Journal of Infectious Diseases*, 143:743-746.

Centers for Disease Control and Prevention. Outbreaks of *Salmonella* Serotype Enteritidis Infection Associated with Consumption of Raw Shell Eggs- United States, 1994-1995. *MMWR*, 1996. 45: 737-747.

Centers for Disease Control and Prevention. Surveillance for Foodborne-Disease Outbreaks-United States, 1993-1997. *Morbidity and Mortality Weekly Report* March 17, 2000;*49*:1-63.

D'Aoust JY (1991) Pathogenicity of foodborne *Salmonella*. *International Journal of Food Microbiology*, 12:17-40.

D'Aoust JY (1997) *Salmonella* Species. In: Doyle MP, Beuchat LR, Montville TJ, eds, *Food microbiology: Fundamentals and frontiers*. Washington, DC, American Society for

Microbiology Press, pp.

Guthrie RK. (1992). *Salmonella* CRC Press, Boca Raton Ann Arbor London.

Frenzen PD, Riggs TL, Buzby JC, Breuer T, Roberts T, Voetsch D, Reddy S, FoodNet

Working Group (1999) *Salmonella* cost estimate updated using FoodNet data. *FoodReview*, 22:10-15.

Headrick M and Cray P. Antimicrobial Susceptibility Patterns for *Salmonella* Isolates of Animal Origin, NARMS 1999. *From a poster presented at the American Society of Microbiologists (ASM) Meeting held May 20 – 24, 2001, in Orlando, FL.*

Kapperud G, Stenwig H, Lassen J (1998a) Epidemiology of *Salmonella typhimurium* O:4-12 infection in Norway: evidence of transmission from an avian wildlife reservoir. *American Journal of Epidemiology*, 147:774-782.

Latimer, HK. Quantitative Microbial Risk Assessment for Human Salmonellosis Associated with the Consumption of Raw Shell Eggs. 1999. PhD Dissertation. Chapel Hill, NC.

Le Bacq F, Louwagie B, Verhaegen J (1973) *Salmonella typhimurium* and *Salmonella*

enteritidis: changing epidemiology from 1973 until 1992. *European Journal of Epidemiology*, 10:367-371.

Lee LA, Puhr ND, Maloney EK, Bean NH, Tauxe RV (1994) Increase in antimicrobial-

Resistant Salmonella infections in the United States, 1989-1990. *Journal of Infectious*

Diseases, 170:128-134.

Mead PS, Slutsker L, Dietz V, McCraig LF, Bresee JS, Shapiro C, Griffin PM, Tauxe RV (1999) Food-related illness and death in the United States. *Emerging Infectious Diseases*,

5:607-625.

Murray MJ (1986) Salmonella: virulence factors and enteric salmonellosis. *Journal of the American Veterinary Medical Association*, 189:145-147.

Slauch J, Taylor R, Maloy S (1997) Survival in a cruel world: how Vibrio cholerae and

Salmonella respond to an unwilling host. *Genes and Development*, 11:1761-1774.

Tacconelli E, Tumbarello M, Ventura G, Leone F, Cauda R, Ortona L (1998) Risk factors, nutritional status, and quality of life in HIV-infected patients with enteric salmonellosis. *Italian Journal of Gastroenterology and Hepatology*, 30:167-172.

Thorns CJ (2000) Bacterial food-borne zoonoses. *Revenue Scientifique et Technique Office International des Epizooties*, 19(1): 226-239.

WHO Expert Committee. Salmonellosis control: the role of animal and product hygiene, Tech Rep. Ser. No. 774, World Health Organization, Geneva, 1988

Wong SS, Yuen KY, Yam WC, Lee TY, Chau PY (1994) Changing epidemiology of human salmonellosis in Hong Kong, 1982-93. *Epidemiology and Infection*, 113:425-434.

Tables and Figures

Table 1: Food vehicles implicated in Foodborne Outbreaks due to *Salmonella* spp., United States, 1993-1997.[1]

	1993	1994	1995	1996	1997	Total
Beef	-	7	4	1	2	14
Chicken	1	-	2	1	2	6
Pork	1	1	1	1	-	4
Eggs	3	2	6	3	3	17
Ice Cream	3	3	-	5	-	11
Total known	39	40	44	36	25	184
Total unknown	29	30	46	33	35	173

1. CDC. "Surveillance for Foodborne-Disease Outbreaks-United States, 1993-1997". *Morbidity and Mortality Weekly Report* March 17, 2000;*49*:1-63.

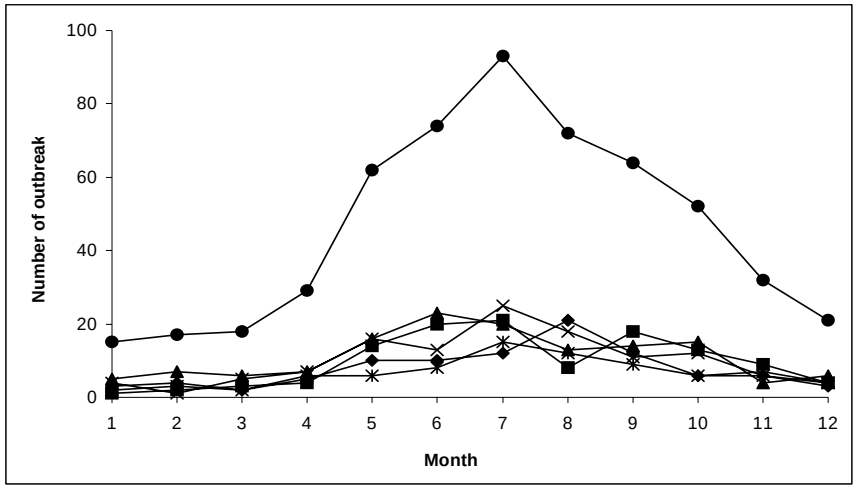

Figure 1. Temporal Distribution of Foodborne disease outbreak from *Salmonella* in the United State including Guam, Puerto Rico, and the U.S. Virgin Islands in 1988-1992 (CDC, 1996, from Latimer, 1999).