Food and Agriculture Organization of the United Nations

World Health Organization

Joint FAO/WHO Expert Meeting on the pre- and post-harvest control of non-typhoidal *Salmonella* spp. in poultry meat

WHO HQ, Geneva, Switzerland: 12 - 16 September 2022

SUMMARY AND CONCLUSIONS

Issued in October 2022

The Joint FAO/WHO Expert Meeting on Microbial Risk Assessment (JEMRA) on the pre- and post-harvest control of non-typhoidal *Salmonella* spp. in poultry meat was convened to review recent data and evidence on the topic and to provide scientific advice on control measures for non-typhoidal *Salmonella* spp. in the broiler production chain.

Dr Catherine M Logue served as Chairperson. Dr Marianne Chemaly served as Rapporteur. This document summarizes the conclusions of the meeting on the pre- and post-harvest control of non-typhoidal *Salmonella* spp. in poultry meat and is being made available to facilitate the deliberations of the upcoming Codex Committee on Food Hygiene (CCFH). The full report will be published as part of the Food and Agriculture Organization (FAO) and World Health Organization (WHO) Microbiological Risk Assessment (MRA) Series.

The meeting participants are listed in Annex 1 of this summary report.

More information on this work is available at:

http://www.fao.org/food-safety/en/

and

https://www.who.int/foodsafety/en/

Scope and objectives

In response to a request from the 52nd Session of the Codex Committee on Food Hygiene (CCFH), the FAO/WHO Joint Expert Meeting on Microbiological Risk Assessment (JEMRA) convened a meeting in Geneva, Switzerland from 12-16 September 2022, to collate and assess the most recent scientific information relevant to the control of non-typhoidal (NT)-*Salmonella* spp. in chicken meat, including a review of the Codex *Guidelines for the Control of Campylobacter and Salmonella in Chicken Meat* (CXG 78-2011)[1]. The group of subject matter experts (Annex 1) reviewed the available data on NT *Salmonella* spp. control in the broiler production chain, including scientific literature published since 2008 and data submitted in response to a call for data for this meeting. The experts: 1) determined the extent to which various control measures, good hygienic practice (GHP) or hazard-based control measures (targeted to reduce NT-*Salmonella* spp.), had adequate evidence to assess their efficacy; 2) evaluated the impact or efficacy of control measures relevant to NT-*Salmonella* spp. in the broiler production chain, noting the variability of the impact reviewed and recommended revisions to the *Guidelines for the Control of Campylobacter and* Salmonella *in Chicken Meat* (CXG 78-2011), Paragraphs 1 to 114, based on the currently available evidence (Annex 2).

Based on evaluation criteria such as the number, quality, applicability and representativeness of reports and research on a particular intervention available for screening, many control measures lacked sufficient evidence to allow the experts to assess their effectiveness.

Conclusions

The expert consultation noted that no single control measure was sufficiently effective at reducing either the prevalence or the level of contamination of broilers and poultry meat with NT-*Salmonella* spp. Instead, it was emphasized that control strategies based on multiple intervention steps (multiple or multi-hurdle) would provide the greatest impact in controlling NT-*Salmonella* spp. in the broiler production chain.

The expert consultation concluded the following:

Primary production interventions for the control of NT-*Salmonella* spp.

Biosecurity and management approaches for the control of NT-*Salmonella* spp.

- At all levels of farm production, stringent biosecurity measures including sanitation and hygiene are important factors to prevent and control NT-*Salmonella* spp. in flocks.
- It is important for breeding flocks to be NT-*Salmonella*-free, and this begins at the parent/grandparent flock level and in the production environment.

Vaccination-based approaches for the control of NT-*Salmonella* spp.

- Vaccine-based strategies reduce the prevalence and/or level of shedding of NT-*Salmonella* spp. in flocks but do not eliminate NT-*Salmonella* spp.

Antimicrobial approaches for the control of NT-*Salmonella* spp.

[1] https://www.fao.org/fao-who-codexalimentarius/sh-proxy/de/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCXG%2B78-2011%252FCXG_078e.pdf

- There was no strong evidence that the use of substances with antimicrobial activity such as additives in feed and water resulted in effective control of NT- *Salmonella* spp. in broilers.

Competitive exclusion/probiotics approaches for the control of NT-*Salmonella* spp.

- A promising strategy for NT-*Salmonella* spp. control was a combination of different competitive exclusion products (e.g., probiotics and prebiotics) but there was a limited number of published studies using naturally contaminated chicks and/or under commercial conditions to allow for adequate conclusions.

Feed and water characteristics and management approaches for the control of NT-*Salmonella* spp.

- The efficacy of specific feed- and water-based strategies were study-specific and dependent upon the physiological status of both the pathogen and the animal, the broiler gastrointestinal tract environment, the concentration of the additive, and the method of its application.
- The use of feed modifications, including the acidification of feed and water, are not stand-alone hazard-based control measures for the control of NT-*Salmonella* spp. in poultry. However, feed-based strategies, when used in conjunction with good hygienic practices, may further reduce NT-*Salmonella* spp. in poultry.
- Based on the information available, further studies are needed to assess how extensive scale application of modified feed and management approaches could impact NT-*Salmonella* spp. levels

Bacteriophage-based approaches for the control of NT-*Salmonella* spp.

- There is limited information as to the effectiveness of bacteriophage-based control of NT-*Salmonella* spp. at the farm level. Further research is needed, especially in the long-term efficacy of bacteriophage-based control.

Processing interventions for the control of NT-*Salmonella* spp.

- Good hygienic practices are important in minimizing the risk of NT-*Salmonella* spp. contamination during slaughter and processing.
- The effect of processing interventions on NT-*Salmonella* spp. are influenced by a variety of conditions, including but not limited to characteristics of the NT-*Salmonella* strain, pH, agent concentration, temperature, contact time, absorbed dose, product characteristics, and processing parameters.
- There was extensive information on the use of water additives, but the current scientific literature is not sufficient to draw objective conclusions regarding the effectiveness of some of them. However, chlorine-based compounds and organic acids (lactic acid, peroxy acetic acid (PAA), and acidified chlorate solutions) showed potential effectiveness.
- High pressure processing may be effective in reducing NT-*Salmonella* spp. in poultry meat.
- An extensive body of scientific evidence suggested that ionizing radiation can achieve any level of NT-*Salmonella* spp. reduction from pasteurization to complete sterility.

- Other interventions or combinations of interventions, including but not limited to novel additives, thermal processes and physical treatments applied to the meat still require further refinement.

Post-processing interventions for the control of NT-*Salmonella* spp.

- Control measures applied during processing may extend shelf-life and control the growth of NT-*Salmonella* spp. at the retail or consumer level, however, the literature in this area is sparse and the application of post-processing interventions needs further examination to assess feasibility.
- Emphasis should be placed on encouraging a positive food safety culture through human behavior and consumer education as it applies to transport, storage, handling and cooking practices.

The experts highlighted several paragraphs in the G*uidelines for the Control of Campylobacter and Salmonella in Chicken Meat* (CXG 78-2011) that could benefit from an update (Annex 2).

Other factors that the expert panel considered that have the potential to impact NT-*Salmonella* spp. control strategies in the future included changes in climate, broiler value chain, human behavior and awareness, food safety culture, pathogens and their hosts. With the advent of next generation technologies including machine learning, omics, tools for traceability and a better understanding of the interactions between *Salmonella* and the microbiome will lead to more accurate quantitative microbial risk assessments (QMRA) and improved One Health.

Annex 1: List of participants

EXPERTS

Nicolas Barro, Burkina Faso

Pablo Chacana, Argentina

Marianne Chemaly, France

Alessandra De Cesare, Italy

Ihab Habib, the United Arab Emirates

Catherine M Logue, the United States of America

Kudakwashe Magwedere, South Africa

Sandeep Tamber, Canada

Elina Tast-Lahti, Sweden

Hajime Toyofuku, Japan

RESOURCE PERSONS

James S Dickson, the United States of America

J. Stan Bailey, the United States of America

Jose Emilio Esteban, the United States of America

Sarah Cahill, Joint FAO/WHO Food Standards Programme, Italy

SECRETARIAT

Akio Hasegawa, WHO, Switzerland

Christine Kopko, FAO, Italy

Jeffrey LeJeune, FAO, Italy

Juliana de Oliveira Mota, WHO, Switzerland

Moez Sanaa, WHO, Switzerland

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Annex 2: Recommended revisions to the Guidelines for the Control of *Campylobacter* and *Salmonella* in Chicken Meat (GXG 78-2011), as they relate specifically to the control of NT-*Salmonella* spp.

Para.	CAC/GL 78-2011	JEMRA Recommendations
3.	Good hygienic practice (GHP) - based. They are generally qualitative in nature and are based on empirical scientific knowledge and experience. They are usually prescriptive and may differ considerably between countries. Hazard-based. They are developed from scientific knowledge of the likely level of control of a hazard at a step (or series of steps) in a food chain, have a quantitative base in the prevalence and/or concentration of *Campylobacter* or *Salmonella*, and can be validated as to their efficacy in hazard control at the step. The benefit of a hazard-based measure cannot be exactly determined without a specific risk assessment; however, any significant reduction in pathogen prevalence and / or concentration is expected to provide significant human health benefit.	• To align the definition of GHP with the definition provided within the General Principles of Food Hygiene (CXC 1-1969). • To consider revising the definition of hazard base to read, *" ...of Campylobacter and/or Salmonella...; … significant reduction in hazard prevalence and/or concentration..."*; and • To review the statement *"any significant reduction in pathogen prevalence is expected to provide significant human health benefits"*.
9.	Scope	• To expand the scope to include ground chicken meat, organ meat, and chicken products made from comminuted meat.
4 Definition – Competitive exclusion	Probiotics are defined competitive exclusion products (footnote 7)	• To consider changing the text in the footnote to read, "*Probiotics may be competitive exclusion products"*. • Verify the alignment with WOAH definition of completive exclusion in chapter 6.6
4 Definition – Competitive exclusion		• To consider including a definition for a production lot as per the Guidelines on the management of biological foodborne outbreaks (For adoption at Step 8 - Report of the 52nd session of the CCFH.) • *Lot: A definite quantity of ingredients or of a food that is intended to have uniform character and quality, within specified*

		limits, is produced, packaged and labelled under the same conditions, and is assigned a unique reference identification by the food business operator. It may also be referred to as a "batch".
18.	Food Safety Risk Profile for *Salmonella* species in broiler (young) chicken, June 2007. Food Safety Risk Profile for *Campylobacter* species in broiler (young) chicken, June 2007.	• To verify that the links referenced in the footnote are current and active. • To evaluate paragraph 18 and to consider updating it, if needed.
24.	Control of *Campylobacter* and *Salmonella* in grandparent flocks is strengthened 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 in consultation with relevant stakeholders.	• To consider including a definition for biosecurity that includes personal hygiene. • May want to align with WOAH definition: https://www.woah.org/fileadmin/Home/eng/Health_standards/tahc/current/glossaire.pdf. • To consider changing the text to read "*…by the application of effective biosecurity measures."*
26.	Where a flock is found to be *Salmonella*-positive a range of responses, detailed in the OIE Terrestrial Animal Health Code[19], Chapter 6.5 "Prevention, Detection and Control of *Salmonella* in Poultry", should be taken.	• To update the WOAH reference "Terrestrial Animal Health Code, Chapter 6.6 - Prevention, Detection and Control of *Salmonella* in Poultry"
29.	Only eggs from *Salmonella*-negative flocks should be sent for hatching. When this is not practical, the eggs from *Salmonella*-positive flocks should be transported separately from other eggs.	• To consider revising the guidance so that "Only eggs from *Salmonella*-negative flocks should be transported for hatching. The eggs from *Salmonella*-positive flocks should be transported separately and discarded/not used for propagation/handled according to competent authority. "
31.	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 contamination to the infected breeding	• To verify that the guidance is aligned with the most recent version of WOAH. Several references identified egg disinfection as a means of reducing *Salmonella* in chicks after hatching.

	flocks should be performed and control measures should be reviewed.	• A suggestion for reformulation: *"Where the use of eggs from flocks that are known to be infected is unavoidable"* (thus replacing the word contaminated with infected).
35.	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 and the chicks should be kept isolated from other flocks. Trace back of contamination to the infected breeding flocks should be performed and control measures should be reviewed.	• To verify that the guidance is aligned with the most recent version of WOAH. Several references identified egg disinfection as a means of reducing *Salmonella* in chicks after hatching. • To consider revising the text to read, *"Where the use of eggs from flocks that are known to be infected is unavoidable"*, thus replacing the word contaminated with infected.
37.	Personnel should follow appropriate biosecurity procedures to avoid cross contamination of day old chicks during loading and unloading. All live bird transport crates and modules should be cleaned, disinfected and dried to the greatest extent practicable before re-use.	• To consider revising the text to read, "*All live bird transport trucks, crates and modules should be effectively cleaned, disinfected and dried on site to the greatest extent practicable, before reuse."*
44.	All live bird transport crates and modules should be cleaned, disinfected and dried to the greatest extent practicable, before reuse.	• To consider revising the text to read, *"All live bird transport trucks, crates and modules should be effectively cleaned, disinfected and dried on site to the greatest extent practicable, before reuse."*
46.	Flocks, where practical, should be slaughtered after 8-12 hours feed withdrawal in order to reduce the likelihood of contamination of carcasses by faecal material and ingesta.	• To consider aligning the text with recent scientific studies on proper fasting time could reduce the goal of carcass contamination.
54.	Washing with abundant potable running water	• To consider replacing potable water with fit for purpose water to align with CXG1-1969, paragraph 70. Text should be adjusted to fit for purpose water.
60.	Cross contamination at defeathering can be minimised by:	• To consider revising the text to read, "*Washing carcasses prior to scalding can*

		reduce contamination prior to defeathering."
64.	Spray applications of 20-50 ppm chlorinated water following defeathering and carcass evisceration have been shown to reduce the prevalence of *Salmonella*-positive broiler carcasses from 34% to 26% and from 45% to 36%respectively.	• To consider including generic statement rather than specific processing parameters for paragraphs 64-73. • To also consider replacing references to trisodium phosphate (TSP) with the following text: "*Several different chemistries have been demonstrated to be effective in reducing carcass contamination at different washing steps."*
65.	Immersion in Tri Sodium Phosphate (TSP) has been shown to reduce prevalence of *Salmonella*- positive carcasses from 72% to 4%	• To consider including generic statement rather than specific processing parameters for paragraphs 64-73.
66.	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. The removal of contaminants may be aided by the use of brushing apparatus installed in line with the inside/outside wash.	• To consider including generic statement rather than specific processing parameters for paragraphs 64-73.
68.	Inside/outside washing using a spray application of 20-50 ppm chlorinated water has been shown to reduce the prevalence of *Salmonella*-positive broiler carcasses from 25% to 20%. A second inside/outside washing following upon the first resulted in a reduction of *Salmonella*-positive broiler carcasses from 16% to 12%.	• To consider including generic statement rather than specific processing parameters for paragraphs 64-73.
69.	An on-line reprocessing spray system incorporating ASC has been shown to reduce *Campylobacter* in the whole carcass rinse sample by about 2.1 $\log_{10}$ CFU/ml and to reduce the prevalence of	• To consider including generic statement rather than specific processing parameters for paragraphs 64-73.

	Salmonella- positive carcasses from 37% to 10%.	
70.	Dipping carcasses in 10% TSP reduced Campy by 1.7 log10 CFU/g neck skin and the MPN of *Salmonella* was reduced from 1.92 log10 CFU neck skin to undetectable levels.	• To consider including generic statement rather than specific processing parameters for paragraphs 64-73.
71.	The use of ASC (750ppm, pH 2.5, spray application) has in one industrial setting been shown to reduce *Salmonella* prevalence on carcasses from about 50% to levels below detection. In another industrial setting *Salmonella* prevalence was reduced by 18% (700-900ppm, pH 2.5, spray application).	• To consider including generic statement rather than specific processing parameters for paragraphs 64-73.
72.	A pre-chill ASC spray reduced the *Salmonella* prevalence on carcasses from 17% to 9%. Dipping carcass parts in ASC reduced the *Salmonella* prevalence from 29% to 1%.	• To consider including generic statement rather than specific processing parameters for paragraphs 64-73.
73.	Spray application of 8-12% TSP immediately before carcass chilling was shown to reduce *Salmonella* from 10% to 3%	• To consider including generic statement rather than specific processing parameters for paragraphs 64-73.
79.	Water (including recirculated water) should be potable and the chilling system may comprise of 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 and washing action.	• To consider replacing potable water with fit for purpose water to align with CXG1-1969, paragraph 70.
83.	Immersion chilling in water treated with 20ppm or 34 ppm chlorine or 3ppm or 5 ppm chlorine dioxide reduced *Salmonella* prevalence from 14% in controls to 2% (20ppm Cl_2), 5% (34ppm Cl_2), 2% (3ppm ClO_2) and 1% (5 ppm ClO_2) respectively.	• To consider including generic statement rather than specific processing parameters for paragraphs 83-88. • To consider revising the text to read "*Immersion chilling in water treated with chemical disinfectants (e.g., chlorinated compounds, organic acids) can reduce Salmonella prevalence.*"

85.	The use of ASC (750 ppm, pH ≈ 2.5, immersion dip) post-chill has been shown to reduce prevalence of *Salmonella* positive carcasses from 16% to a level below detection.[5]	• To consider including generic statement rather than specific processing parameters for paragraphs 83-88.
86.	Spray applications of 20-50 ppm chlorinated water have been shown to reduce the prevalence of *Salmonella*-positive carcasses from 10% to 4%.	• To consider including generic statement rather than specific processing parameters for paragraphs 83-88.
87.	A chlorine dioxide generating system applied as a dip at 5ppm post-chill resulted in 15-25% reduction in *Salmonella* prevalence.[5]	• To consider including generic statement rather than specific processing parameters for paragraphs 83-88.
88.	Spraying carcasses immediately after spin chilling with 10% TSP resulted in a reduction of *Salmonella* from 50 to 6 %	• To consider including generic statement rather than specific processing parameters for paragraphs 83-88. • To consider also replacing references to trisodium phosphate (TSP) with the following text "*Several different chemistries have been demonstrated to be effective in reducing carcass contamination at different washing steps."*
89.	Chilled carcasses should be held in temperature-controlled environments and processed as soon as possible, or with the addition of ice to minimise the growth of *Salmonella*.	• To consider water and ice references in conjunction with CXG1-1969, para 70.
92.	Chilled carcasses should be held in temperature-controlled environments and processed as soon as possible or with the addition of ice to minimise the growth of *Salmonella*.	• To consider water and ice references in conjunction with CXG1-1969, para 70.
97.	For GHP-based control measures for all aspects of transport, refer to the Code of Practice – General Principles of Food Hygiene (CAC/RCP 1-1969) and the Code of Hygienic Practice for Meat (CAC/RCP 58- 2005).	• To consider water and ice references in conjunction with CXG1-1969, para 70.

10.1	Step 25: Transport	• To consider also including the same text for temperature under the transport step. *"Products should be transported at temperatures preventing the growth of Salmonella."*
99.	Hygiene measures should be in place to prevent cross-contamination between raw chicken meat and other food.	• To consider revising the text to read, *"Hygienic measures should be in place to prevent cross-contamination between raw chicken meat, surfaces, utensils, and other food."*
100.	Retailers should separate raw and cooked products.	• To consider revising the text to read, *"Retailers should separate raw and cooked, ready-to-eat products."*
103 and the footnote 28 in 104.	For GHP-based control measures, also refer to the Code of Hygienic Practice for Precooked and Cooked Foods in Mass Catering (CAC/RCP 39-1993).	• To consider updating the codes, CAC/RCP 39-1993 and CAC/RCP 8-1976.
108.	Chicken meat should be cooked according to a process that is capable of achieving at least a 7 log reduction in both *Campylobacter* and *Salmonella*.[29]	• To consider revising the text to read, "*Chicken meat should be cooked according to a process that is capable of reaching an internal temperature that can inactivate Salmonella, for example 74°C.*"
109.	Consumer education should focus on handling, hand washing, cooking, storage, thawing, prevention of cross contamination, and prevention of temperature abuse. The WHO Five keys to safer food[30] assists in this process.	• To consider revising the text to read, *"Consumer education should focus on handling, hand washing, cooking, storage, thawing, prevention of cross-contamination, and prevention of temperature abuse including during transport…"*
110.	Special attention should be paid to the education of all persons preparing food, and particularly to persons preparing food for the young, old, pregnant and immuno-compromised.	• To consider revising the text to read, "*Special attention should be paid to the education of all persons preparing food, and particularly to persons preparing food for vulnerable populations (e.g., the young, elderly, and those with compromised immunity)"*

111.	The above information to consumers should be provided through multiple channels such as national media, health care professionals, food hygiene trainers, product labels, pamphlets, school curricula and cooking demonstrations.	• To consider revising the text to read, *"The above information to consumers should be provided in appropriate languages and forms. Multiple channels such as the internet, media, public health providers, healthcare professionals, food hygiene trainers, product labels, posters and pamphlets, school curricula and cooking demonstrations should be considered when disseminating educational information."*
112.	Washing of raw chicken in the kitchen should be discouraged so as to minimise the possibility of contamination of other foods and surfaces that come in contact with food and humans. Where deemed necessary washing of raw chicken carcasses and/or chicken meat, should be carried out in a manner which minimises the possibility of contamination of other foods and surfaces that come in contact with other foods and humans	• To consider removing the following text *"Where deemed necessary washing of raw chicken carcasses and/or chicken meat, should be carried out in a manner which minimises the possibility of contamination of other foods and surfaces that come in contact with other foods and humans."*
114.	Products should be stored at temperatures preventing growth of *Salmonella*.	• To consider revising the text to read, *"Products should be transported and stored at temperatures preventing the growth of Salmonella."*
115.	Chicken meat should be cooked according to a process that is capable of achieving at least a 7 log reduction in both *Campylobacter* and *Salmonella*[31]	• To consider revising the text to read, "*Chicken meat should be cooked according to a process that is capable of reaching an internal temperature that can inactivate Salmonella, for example 74°C*."