Food and Agriculture Organization of the United Nations

World Health Organization

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

FAO, HQ, Rome, Italy: 6-10 February 2023

SUMMARY AND CONCLUSIONS

Issued in March 2023

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

This document summarizes the conclusions of the meeting on the pre- and post-harvest control of *Campylobacter* 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 Rome, Italy from 6-10 February 2023, to collate and assess the most recent scientific information relevant to the control of thermotolerant *Campylobacter* species *C. jejuni* and *C. coli* (hereafter *Campylobacter*) in broiler production and chicken meat, including a review of the Codex *Guidelines for the Control of* Campylobacter *and* Salmonella *in Chicken Meat* (CXG 78-2011)[1].

The scope was focused on aspects of broiler primary production from the point of chick placement into production facilities to consumer handling.

The objectives were to identify and assess control measures for *Campylobacter* in the broiler production chain. The expert committee (Annex 1) reviewed the available data on *Campylobacter* control including scientific literature published between 2008 to October 2022 and data submitted in response to a call for data for this meeting. The experts: 1) determined the quality and quantity of evidence of control measures for *Campylobacter,* 2) evaluated the impact of measures to control *Campylobacter* in the broiler production chain, 3) determined which hazard-based interventions pertained specifically to *Campylobacter* and which were general to the control of foodborne pathogens in the pre- and post-harvest broiler production chain, 4) reviewed and recommended revisions to the *Guidelines for the Control of* Campylobacter *and* Salmonella *in Chicken Meat* (CXG 78-2011), paragraphs 1 to 115, based on the currently available scientific evidence (Annex 2).

Control measure evaluation began at the time of chick placement since there is currently no evidence that parent flocks or hatchery practices contribute to the colonization of broiler chicks. The available literature on interventions was predominantly based on laboratory and pilot studies, with few commercial scale applications, therefore limited conclusions could be reached. The experts recommend the use of a combination of multiple interventions (multi-hurdle approach) suitable to production and processing stages to lower *Campylobacter* contamination on chicken meat.

Conclusions

A number of interventions were identified through primary production to post-processing stages. The expert consultation concluded the following in each stage of production:

Assessment of primary production interventions for the control of *Campylobacter*

Biosecurity and management approaches

- Using strict biosecurity measures (hygiene practices and sanitation) can enhance the control of *Campylobacter* in broiler flocks.
- Risk factors for *Campylobacter* contamination at primary production establishments, such as partial depopulation, litter management, down period length, proximity to other livestock and slaughter age can help guide intervention strategies.

[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

Vaccination-based approaches

- Currently there are no commercial vaccines for *Campylobacter* readily available for any stage of primary production and vaccination studies were limited to *C. jejuni* only.
- Several potential vaccine candidates are in the proof-of-concept phase but cannot be considered yet as an intervention.
- Some vaccines induced a cellular or humoral response in the chicken host, but this did not always translate to reduced cecal colonization by *Campylobacter* in pilot studies.

Bacteriophage-based approaches

- There are currently no commercial products available for use in primary production.
- The effects of phage therapy may be transitory and prone to resistance.

Feed and water additives

Organic acids

- In feed, short- and medium- chain fatty acids, and in particular, caprylic acid shows promise as a feed additive in reducing *Campylobacter* in pilot studies.
- In water, organic acids reduced *Campylobacter* in cecal/fecal specimens at the end of the primary production period; however, the effects were not sustained to the end of production in pilot studies.

Probiotics

- In feed, there is inconsistent evidence on the efficacy of probiotics as an intervention for reducing *Campylobacter* in broilers at primary production level.

Plant-based additives

- In feed, the efficacy of some plant-based molecules in *in vivo* pilot studies showed limited reduction of *Campylobacte*r in cecal/fecal specimens at the end of the primary production period.

Assessment of processing interventions for the control of *Campylobacter*

- Good hygienic practices during processing are important in minimizing *Campylobacter* contamination on meat.
- The effectiveness of interventions during processing is dependent upon the incoming flock prevalence and concentration of *Campylobacter* in the gastrointestinal tract and on the bird.
- The impact of processing practices can be enhanced by a combination of multi-hurdle approach, processing effects, physical, and/or chemical interventions.

Processing effects

- Logistic slaughter scheduling can reduce *Campylobacte*r cross-contamination.

- Qualitative and quantitative targets for *Campylobacter* may be used to optimize process control.
- Scalding reduces the carcass surface concentration and prevalence of *Campylobacter*, and its effect depends on the temperature, and dilution effect.
- Defeathering and evisceration may increase both prevalence and concentration of *Campylobacter* on carcasses.
- Immersion chilling can reduce (dilute) the carcass concentration of *Campylobacter*; however, this is dependent on the initial *Campylobacter* load on the incoming birds.
- In combination with processing aids, immersion chilling, may reduce the carcass prevalence of *Campylobacter*.
- Air chilling may reduce concentration of *Campylobacter* but the efficacy of air chilling in reducing prevalence of *Campylobacter* when used without other processing aids is inconclusive.

Physical

- Irradiation is effective at eliminating *Campylobacter* on meat.
- Freezing meat reduces the concentration of *Campylobacter.*
- Steam, ultrasonication, high-intensity light pulse, visible light, UV-C and other technologies have shown promise either at the laboratory or pilot scale but their impact is unknown at commercial scale.

Chemical

- Processing aids such as chlorine derivatives, peroxyacetic acids, and organic acids added to water used for washing and or dipping may reduce *Campylobacter* on carcasses.
- Some marination ingredients have shown reductions in *Campylobacter* on meat.

Post-processing interventions for the control of *Campylobacter*

- Thorough cooking is effective at eliminating *Campylobacter* on meat.
- The application of good hygiene practices is important in reducing *Campylobacter* on meat.
- Freezing meat reduces the concentration of *Campylobacter.*
- Some marination ingredients have shown reductions in *Campylobacter* on meat.

Available evidence for the reduction of *Campylobacter* was primarily focused on *C. jejuni* and *C. coli.* Interventions aimed at foodborne pathogens such as irradiation or thorough cooking are effective in eliminating *Campylobacter* on meat. Hazard-based interventions, good agriculture practices and hygienic practices for the general control of foodborne pathogens, may be effective for the reduction of *Campylobacter*. There are no interventions that **specifically** control *Campylobacter* on meat.

The experts recognize further data gaps exist and that new technologies may offer promising approaches to reducing *Campylobacter* on poultry. Further global changes to the industry, growing of global populations, climate change, and increased demand for animal protein in specific regions will guide the need for further control measure assessments.

Annex 1: List of participants

EXPERTS

Marianne Chemaly, French Agency for Food, Environmental and Occupational Health & Safety, France

Frances Colles, University of Oxford, the United Kingdom

Alessandra De Cesare, Department of Veterinary Medical Sciences, University of Bologna, Italy

Moses Gathura Gichia, Food Safety Consultant, Nairobi, Kenya

Ihab Habib, College of Agriculture and Veterinary Medicine United Arab Emirates University, the United Arab Emirates

Nicol Janecko, Quadram Institute Bioscience, the United Kingdom (served as Rapporteur)

Catherine M Logue, Department of Population Health, College of Veterinary Medicine, University of Georgia, the United States of America

Marcos Sanchez-Plata, Texas Tech University, the United States of America

Elina Tast-Lahti, National Veterinary Institute, Sweden

Jaap Wagenaar, Faculty of Veterinary Medicine, Utrecht University, the Netherlands (served as Chair)

Bing Wang, University of Nebraska-Lincoln, the United States of America

RESOURCE PERSONS

Jose Emilio Esteban, Codex Committee on Food Hygiene, the United States of America

Evelyne Mbandi, Codex Committee on Food Hygiene, the United States of America

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

Jorge Pinto Ferreira, FAO, Italy

SECRETARIAT

Akio Hasegawa, WHO, Switzerland

Christine Kopko, FAO, Italy

Jeffrey LeJeune, FAO, Italy

Juliana de Oliveira Mota, WHO, Switzerland

Moez Sanaa, WHO, Switzerland

Kang Zhou, FAO, Italy

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 *Campylobacter* spp.

Para.	CAC/GL 78-2011	JEMRA Recommendations
5.	The Guidelines are presented in a flow diagram format so as to enhance practical application of a primary production-to-consumption approach to food safety. This format: • Demonstrates differences and commonalities in approach for control measures for *Campylobacter* and *Salmonella.* • … • Facilitates development of HACCP plans at individual premises and national levels.	• To consider updating the last bullet to read: *"Facilitate development of HACCP and **risk assessment** plans at individual premises…"*
9.	Scope	• Consider clarifying the scope to include: **thermotolerant** *Campylobacter* and **non-Typhoidal** *Salmonella*.
12.	The Guidelines systematically present GHP-based control measures and examples of hazard-based control measures. GHP is a pre-requisite to making choices on hazard-based control measures…Government and industry can use choices on hazard-based control measures to inform decisions on critical control points (CCPs) when applying HACCP principles to a particular food process.	• Consider the following addition: *"...(CCPs) and relative risk reduction when applying HACCP and **risk assessment** principles to particular food process."*

Para.	CAC/GL 78-2011	JEMRA Recommendations
4.	Definitions	Support the following recommendation from the JEMRA meeting on *Salmonella* controls: • To consider including a definition for a production lot as per the Guidelines on the management of biological foodborne outbreaks. • *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".*
16.	5. PRINCIPLES APPLYING TO CONTROL OF *CAMPYLOBACTER* AND *SALMONELLA* IN CHICKEN MEAT Overarching.... i. The principles of food safety risk analysis should be incorporated wherever possible and appropriate in the control of *Campylobacter* and *Salmonella* in chicken meat from primary production to consumption ii. Wherever possible and practical, Competent Authorities....	• Consider the following editorial change: "*5i) The principles of food safety risk analysis should be incorporated* ***to the extent possible and as appropriate...*****"** and "*5ii)* ***To the extent possible and as appropriate,*** *Competent Authorities should..."*
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.	Support the following recommendation from the JEMRA meeting on *Salmonella* controls: • To verify that the links referenced in the footnote are current and active. • To evaluate paragraph 18 and to consider updating it, if needed.

Para.	CAC/GL 78-2011	JEMRA Recommendations
Section 7	PRIMARY PRODUCTION-TO-CONSUMPTION APPROACH TO CONTROL MEASURES	Consider the following updates to account for religious practices that do not include stunning: • Process Flow Diagram 2: Step 14 - slaughter: B1) with stunning B2) without stunning, then A) Hang, then B1) split into Gas and Electrical Consider tick marks in *Campylobacter* column in the summary table for: • Receive at Slaughterhouse (use Establishment as a term). • Dress (interventions validated for *Campylobacter* during dressing (decontamination). • Portion (interventions directed at portions/parts).
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.	Support the following recommendation from the JEMRA meeting on *Salmonella* controls: • 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."*
32.	Personnel involved in the transportation of day-old chicks to parent flocks should not enter any livestock buildings and should prevent cross contamination of day-old chicks during loading and unloading.	• Consider updating the text to read: "*…transportation of day-old chicks to parent flock* ***establishments****…*''
36.	Personnel involved in the transportation of day-old chicks should not enter any livestock buildings.	• Consider changing "livestock buildings" to "*…livestock* ***establishments."***

Para.	CAC/GL 78-2011	JEMRA Recommendations
40.	The use of fly screens to reduce or eliminate fly infestation in broiler houses has been shown to decrease the percentage of *Campylobacter* spp.-positive flocks from 51.4% to 15.4%.	• Consider revising this guidance as there is no clear evidence since the initial studies on effectiveness. • Consider eliminating the percentages and leave the remainder of the statement. • Consider adding a statement to include fly screens, in combination with high biosecurity measures.
41.	Full depopulation of the flock should be carried out where possible. Where this is not practicable and partial depopulation is practised, particular attention should be paid to strict biosecurity and hygiene of catchers and the equipment they use.	• Consider adding the following to statement paragraph 41: **"Partial depopulation has been shown to be a risk factor for the increase of *Campylobacter* contamination"** as there are several reports on thinning/ depopulation and *Campylobacter* contamination due to biosecurity deficiencies.
45.	Where appropriate to the national situation, information about the flock, in particular about *Salmonella* and/or *Campylobacter* status should be provided in a timely manner to enable logistic slaughter and/or channelling of poultry meat to treatment.	• Consider replacing the word "treatment" with "reduced risk processing", "intervention" or "custom processing".
54.	Washing with abundant potable running water	Support the recommendations from the JEMRA meeting on Salmonella controls: • 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.

Para.	CAC/GL 78-2011	JEMRA Recommendations
59	Other factors that should be taken into account when designing process control systems that minimise contamination during scalding include: • Degree of agitation • Use of multi-staged tanks • … • Tanks being cleaned and disinfected at least daily • Hygiene measures applied to reused/recycled water.	• Consider replacing "daily" with ***"tanks being cleaned and disinfected at an adequate frequency (e.g. end of shift)"*** • Consider adding the following bullet: *"**Directed water scalders**"*
63.	9.4.1.5 Crop removal 63. Where possible, crops should be extracted in a manner that is likely to limit carcass contamination.	• Consider adding the following to section 9.4.1.5: *"**The use of cropper systems allows the release of accumulated dirty water on the carcass cavity, so efforts to remove collected water prior to chilling should be considered.**"*
67.	Carcass washing systems with 1-3 washers using water with 25-35ppm total chlorine have been shown to reduce levels of *Campylobacter* by about 0.5 $\log_{10}$ CFU/ml of whole carcass rinse sample. Post-wash sprays using Acidified Sodium Chlorite (ASC) or TSP may further reduce *Campylobacter* levels by an average of 1.3 $\log_{10}$ CFU/ml or 1.0 $\log_{10}$ CFU/ml of whole carcass rinse sample respectively.	• Consider adding the following statement: *"**Carcass washes with 400 ppm paracetic acid (PAA), showed 1.2 log reductions of Campylobacter prior to chilling.**"*
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 *Salmonella* positive carcasses from 37% to 10%.	• Consider adding the following statement: "***Inside and outside bird washers used for online-reprocessing at 100 ppm of PAA showed 0.5 log reductions of Campylobacter.***"

Para.	CAC/GL 78-2011	JEMRA Recommendations
70.	Dipping carcasses in 10% TSP reduced *Campylobacter* by 1.7 $\log_{10}$ CFU/g neck skin and the MPN of *Salmonella* was reduced from 1.92 $\log_{10}$ CFU/g neck skin to undetectable levels.	• Consider removing the recommendation for TSP since it may not be as commonly used at this time. • Consider adding the following statement: "***Dip treatments in 200 ppm of PAA showed 1.4 log reductions of Campylobacter in carcass rinses***."
78.	The use of chlorine in the chill tank may not act as a decontaminating agent by acting directly on the contaminated carcass. However, there would be a washing off effect by the water itself, and the addition of chlorine at a level sufficient to maintain a free residual in the water would then inactivate *Campylobacter* and *Salmonella* washed off, preventing re-attachment and cross-contamination.	• Consider adding the following statement: "***Immersion chillers using 225 ppm of PAA showed reductions of 1.18 log in concentration and a 76.5% reduction in prevalence of Campylobacter."***
81.	Forced air chilling (blast chilling) may reduce the concentration of *Campylobacter* on chicken carcasses by 0.4 $\log_{10}$ CFU/carcass.	• Consider updating the value and excluding the unit of measure: ***"up to 1 log."***
82.	Immersion chilling has been shown to reduce concentrations of *Campylobacter* by 1.1-1.3 $\log_{10}$ CFU/ml of carcass rinse.	• Consider updating this text to: "*Immersion chilling reduces concentrations of Campylobacter****, and with a combination of processing aids can result in a higher log reduction."***
84.	Immersing whole carcasses in 600-800 ppm ASC at pH 2.5 to 2.7 for 15 seconds immediately post-chill, has been shown to reduce *Campylobacter* by 0.9-1.2 $\log_{10}$ CFU/ml of whole carcass rinse sample.	• Consider adding the following text: "***Post chill tank interventions using sprays of PAA at 1 000 ppm showed up to 2.1 log reductions of Campylobacter.***"

Para.	CAC/GL 78-2011	JEMRA Recommendations
9.10.1	For *Campylobacter*	• Consider adding a new paragraph for Campylobacter and the following text: "***Immersion of chicken wings in 1 000 ppm of PAA for 30 s has been shown to reduce 2.3 logs of Campylobacter***"
94.	Freezing of naturally contaminated carcasses followed by 31 days of storage at -20 degrees C has been shown to reduce C*ampylobacter* by 0.7 to 2.9 log_{10} CFU/g.	• Consider updating this statement to read: *"Freezing of carcasses and portions contaminated with Campylobacter followed by* ***storage at -20 degrees C has been shown to reduce*** **Campylobacter** ***by up to 2 logs."***
95.	Crust freezing using continuous carbon dioxide belt freezing of skinless breast fillets has been shown to give a reduction of *Campylobacte*r of 0.4 log_{10} CFU/fillet.	• Consider updating the statement to include all chicken meat products and not just skinless breast fillets.
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.*	• Consider updating 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 and Campylobacter, for example 74°C."***
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*.	• Consider updating 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 and Campylobacter, for example 74°C."***