CODEX ALIMENTARIUS COMMISSION

Food and Agriculture Organization of the United Nations

World Health Organization

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DISCUSSION PAPER ON THE REVISION OF *GUIDELINES FOR THE CONTROL OF CAMPYLOBACTER AND SALMONELLA IN CHICKEN MEAT* (CXG 78-2011)

(Prepared by USA, Honduras, Brazil and New Zealand)

INTRODUCTION

1. The 52nd session of the Codex Committee on Food Hygiene (CCFH52, 2022) requested that the Joint FAO/WHO Expert Meeting on Microbiological Risk Assessment (JEMRA) collate the relevant scientific information on *Salmonella* and *Campylobacter* in chicken meat in preparation for an update of the existing *Guidelines for the Control of Campylobacter and Salmonella in Chicken Meat* (CXG 78-2011).

2. In response to the request from CCFH52, FAO and WHO organized the first JEMRA meeting on the pre- and post-harvest control of non-typhoidal *Salmonella* spp. from September 12 to 16 2022[a], and the subsequent JEMRA meeting on postharvest control of *Campylobacter* spp. in poultry meat from February 6 to 10, 2023[b]. The two JEMRA meetings have proposed recommended revisions to the *Guidelines for the Control of Campylobacter and Salmonella in Chicken Meat* (CXG 78-2011).

3. CCFH53 noted the intent of the USA, Honduras, Brazil and the EU to prepare a discussion paper on the possible revision of *Guidelines for the Control of Campylobacter and Salmonella in Chicken Meat* (CXG 78-2011) for consideration at CCFH54.

BACKGROUND

Campylobacter

4. *Campylobacter spp.* is a Gram-negative non spore-forming obligate microaerophile that derives characteristic corkscrew motility from the activity of polar flagella and cells are generally present as S-shaped spiral rods. A genome size is typically 1.6 -1.7 Mbps, rich in adenine and thymine and has a commensurate guanine-cytosine content (GC content) of 30%[1]. Organisms of the genus are able to grow at pH between 6.5 and 7.5, and between 37 °C and 42 °C. They lack the necessary heat shock proteins to survive below 30 °C, and are sensitive to water activity (aw) concentrations less than 0.987.[2]

Campylobacter jejuni and human health

5. *Campylobacter* infections are the leading cause of bacterial gastroenteritis in the world, hypothesized to cause infection with as few as 500 ingested cells[1] and in as many as 1 in 4 people around the globe.[3] In the 2010 WHO report, it was estimated that in 2010, *Campylobacter* caused more than 95 million illnesses, 21,374 deaths, and nearly 2,142,000 Disability adjusted life years (DALYs)[c]. Work is currently ongoing to update the global burden of foodborne diseases, including for *Campylobacter* spp.

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[a] The summary report of JEMRA meeting on the pre- and post-harvest control of non-typhoidal *Salmonella* spp. in poultry meat. Available at: https://www.fao.org/3/cc2579en/cc2579en.pdf

[b] The summary report of JEMRA meeting on the pre- and post-harvest control of *Campylobacter* spp. in poultry meat. Available at: https://www.fao.org/3/cc4758en/cc4758en.pdf

[c] One DALY represents the loss of the equivalent of one year of full health. DALYs for a disease or health condition are the sum of the years of life lost to due to premature mortality (YLLs) and the years lived with a disability (YLDs) due to prevalent

6. *C*. *jejuni* is the leading cause of human enteric illness worldwide.[2,9] Chicken meat is one of the important vehicles of transmission of *C. jejuni* to humans. The primary mode of transmission appears to be horizontal and bird colonization can occur at low infectious doses (~35 CFU mL^{-1}).[4,5] The most common point of contamination is during rearing and there is a high risk of cross-contamination in the slaughterhouse and processing environments.[6,7] Efforts should be made to improve Good Hygienic Practices (GHPs), in particular around biosecurity, and hazard controls at these stages and could be addressed in an update to CXG 78-2011.

7. In the JEMRA meeting report on control measures for *Campylobacter,* the benefits of using peroxyacetic acid (PAA) and other organic acids during processing is discussed and both have been shown to reduce pathogen loads in establishments. While the present Codex guideline refers to the use of organic acids, this section could be strengthened to provide current information on the application of specific PAA formulations as with *Salmonella* below.

***Campylobacter* in Poultry**

8. Domestic and wild poultry are a major reservoir of *Campylobacter* with a high prevalence of *C. jejuni* and *C. coli* found in broiler chickens used in commercial production.[5,8] This is challenging from a public health perspective as estimates suggest that poultry is responsible for at least 25% of outbreaks, illnesses, and hospitalizations.[27,28] The three *Campylobacter* species most commonly associated with poultry-related infections are *C*. *jejuni, C*. *coli,* and *C*. *lari.*[9] Commercial farm environments promote horizontal transmission which is recognized as a primary source of *Campylobacter* contamination in commercial chicken flocks.[10]

9. Risk factors from hatchery to processing include the use of contaminated litter which can be mitigated with frequent litter changes, though it should be noted that *Campylobacter* is rarely found in litter associated with sick birds prior to any symptoms, highlighting the importance of routine cleaning rather than cleaning only after a positive detection in litter.

10. Development of risk mitigation measures for *Campylobacter* contamination at primary production sites, including partial depopulation, litter management, down period length, proximity to other livestock, and slaughter age should be considered. Similarly the use of feed and water additives such as short chain fatty acids, peroxyacetic acid (PAA), and caprylic acid should be considered.

11. There is also a high chance of infection during flock transport to processing facilities, making clean transports an important part of reducing cross-contamination.[11]

12. Combining biosecurity measures with routine cleaning of all bird contact points during transport have been shown to significantly reduce contamination of flocks with *Campylobacter.* If implemented systemically these measures can reduce the *Campylobacter* loads entering slaughter facilities.

13. During processing, cross-contamination from the viscera and faeces of infected birds to the meat can occur. In addition to the use of decontamination washes (e.g. PAA), interventions such as chilling and freezing have been shown to reduce *Campylobacter* loads significantly.[12]

14. Combined with routine cleaning, and a robust HACCP plan, food safety systems can reduce the level of the hazard present on poultry meat and can therefore provide a significant and positive impact to any public health system.

Salmonella

15. *Salmonella spp.* is a Gram-negative, non-spore forming, rod-shaped facultative anaerobe belonging to the family Enterobacteriaceae.[13] Responsible for an estimated 49 cases of foodborne illness per 100,000 people per year, this bacterium is the second most common cause of bacterial gastroenteritis globally.[2] While only two species of *Salmonella* are known (*enterica* or *bongori),* the *enterica* species is organized into six subspecies which are further organized into more than 2500 serotypes with 50 serotypes typically involved in the occurrence of disease in humans and animals.[13,14] Pathogen virulence and public health impact can be viewed through the lens of serotypes and virulence genes to better focus surveillance efforts on screening for pathogens of human health concern in the global food supply.

***Salmonella* in Poultry**

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cases of the disease or health condition in a population. WHO 2024 Available at https://www.who.int/data/gho/indicator-metadata-registry/imr-details/158

16. Owing in part to the convenience and efficiency of poultry as a protein source, eggs and poultry are consumed across numerous cultures in a plethora of ways across the globe.[15,16] Demand for poultry continues to increase in developed and developing countries alike.[17] While poultry-associated *Salmonella* outbreaks in the United States accounted for approximately 43% of outbreaks, those outbreaks were predominantly due to cross-contamination prior to cooking or insufficient cooking which highlights the importance of control measures, hazard controls, and testing paradigms that prevent food contaminated with pathogens of human health concern from entering the food chain.[14]

17. Good hygiene practices (GHP) and hazard controls are critical in preventing the spread of pathogens from breeding flocks and in slaughter and production facilities. During carcass dressing, it is recommended to use continuous streams of clean water for washing, removing of excessively dirty carcasses, and chemical interventions may be used for decontamination such as PAA or other chemical interventions approved by relevant authorities.[18] Despite the use of GHPs globally, there remains a significant risk of recontamination during slaughter and processing. Because of this, there remains a high emphasis on hygiene management in processing environments. The optimal approach to reducing the risk of *salmonellosis* to consumers includes limiting both the levels of contamination with pathogens and the number of positive carcasses in slaughter environments.[2]

18. In 2016, the CCFH (48) noted the need for more research on bacteriophage as a control mechanism for *Salmonella* in poultry. More recent publications suggest that this topic should be revisited in the future.[15,19-21] CCFH48 also noted that PAA used in conjunction with lactic acid or chlorine has been shown to reduce *Salmonella* by 1 $\log_{10}$ and should be revisited for application in chicken parts (legs, breast, wings) as these parts are purchased by consumers more frequently than whole carcasses. Finally, the CCFH noted in 2016 that comminuted product is not adequately covered in the current *Guidelines for the control of Campylobacter and Salmonella in chicken meat* (CXG 78-2011**)** and should be revisited. Interventions such as lecithin Cetylpyridinium Chloride (CPC), sodium thiosulfate for PAA, or sodium thiosulfate plus bicarbonate for Acidified Sodium Chlorite (ASC) can reduce the presence of *Salmonella* during drip interventions and should be explored.[17]

Salmonella Outbreaks Associated with Liver Consumption

19. *Salmonella* readily colonizes chicken liver and other organ meat[1] In a study examining the presence and load of *Salmonella* in chicken livers, the pathogen was recovered from over half of the birds testing positive for *Salmonella*.[2] Between 2000-2016, Salmonella was implicated in 17.8% of liver-associated outbreaks[3]. Cases of Salmonella-derived osteomyelitis have been reported and account for 0.45% of reported cases.[4] Rates of Salmonellosis have increased in some countries and taken together, highlights the importance of pre-harvest interventions that reduce or eliminate Salmonella contamination.[4,5] Taken together, these findings highlights the need to revisit, GMP, GHP and hazard controls regarding liver products and potential interventions or testing schemes that can ensure safe consumption.

20. *Salmonella* and *Campylobacter* outbreaks from 2000-2005 resulted in 331 reported illness associated with chicken liver consumption. Cases of *Salmonella*-derived osteomyelitis have been reported and account for 0.45% of reported cases.[26] Rates of salmonellosis have increased in some countries and taken together, highlights the importance of pre-harvest interventions that reduce or eliminate *Salmonella* contamination.[8,26] This report highlights the need to revisit GHP, and hazard controls should be revisited regarding liver products and potential interventions or testing schemes that can provide stronger assurances of safe consumption.

Vaccines as a Preventative Measure against *Salmonella* in poultry

21. Vaccines both live attenuated and inactivated have been developed against several *Salmonella* serotypes of human health concern. These vaccines can help reduce the prevalence of *Salmonella* in poultry through both immunity and competitive exclusion.[26,27]

Screening for Serotypes of Human Health Concern

22. Both the potential to cause illness and the illness severity resulting from an infection is greatly influenced by intrinsic genetic factors of the pathogen. Understanding these factors is critical for fostering a public health apparatus that can respond to priority threats while providing value to all stakeholders through the precise capture of pathogens of public health concern.

23. To date, numerous detection techniques are used to determine serotypes, including immunological assays such as enzyme-linked immunosorbent assay (ELISA), latex agglutination, and immunochromatography, molecular-based assays such as polymerase chain reaction (PCR), loop-mediated isothermal amplification (LAMP), DNA Microarrays, and Whole Genome Sequencing (WGS), and mass spectrometry-based methods such as peptide fingerprinting.[28-30]

24. Serotyping has long been a useful way of identifying which groups of pathogens are of public health concern.[28] The bacterium *Escherichia coli,* for example, includes the serotype O157:H7, which is a well-known pathogen, and serotypes which are commonly associated with pathogenic Shiga toxin-producing *E. coli,* including O26, O45, O103, O111, O121, O145. Public health systems can improve the impact and precision of existing surveillance and testing paradigms by developing assays to detect serotypes of human health concern post-enrichment and in the early stages of laboratory analysis. More research is still needed to develop virulence-based *Salmonella* detection strategies and should be a long term goal.

25. There are many potential approaches to serotyping. The more rapid assays will offer results within a few hours of enrichment and as early in the analysis scheme as practical. One option is a multiplex Real-Time PCR (RT-PCR)-based approach that can detect multiple serotypes of human health concern in an enrichment in one assay. Other assay formats suffer from disadvantages such as being laborious, requiring expensive antisera that may produce ambiguous results, and can miss certain strains due to single nucleotide mutations that inhibit antigen expression.[25] Recent advances in WGS technology have provided an increased understanding of the genetics underlying *Salmonella* pathogenesis and *in silico* tools have been developed that can determine serotype information from sequencing data.[31] While WGS provides a complete record of genetic content, reliance on WGS data for serotype information must be balanced against cost and time requirements.

26. Until recently, RT-PCR approaches suffered from a lack of primer and PCR systems that could identify *Salmonella* serotypes beyond Typhimurium and Enteritidis.[31,32] Using a pangenome distribution of 535 *Salmonella* genomes, researchers recently developed a library of PCR probes and a method to detect 60 of the most commonly occurring *Salmonella* serotypes.[31] RT-PCR assays benefit from being applicable immediately post-enrichment, providing results within a few hours. RT-PCR assays can be designed to meet the needs of a specific region's top public health concerns and can be updated as public health concerns shift over time. This approach provides an accessible way to screen for *Salmonella* serotypes of human health concern while remaining agile.

27. Determining safe background levels of *Salmonella* and being able to collect that data in a high throughput environment has historically been a challenge. Recent advances in RT-PCR have resulted in more robust amplification systems. Serotype information can be combined with quantitative data tracking of contamination levels in various sample types to create a precise testing paradigm that supports regulating *Salmonella* as an adulterant that supports the interests of all stakeholders.

RECOMMENDATIONS

28. In light of the latest scientific information as well as the recommendations from the JEMRA meetings, it is recommended that CCFH undertake new work to revise and update the appropriate text in CXG 78-2011. A project document for this work is provided in Appendix I for consideration by CCFH54.

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Appendix I

PROJECT DOCUMENT FOR THE

NEW WORK PROPOSAL FOR THE REVISION OF *GUIDELINES FOR THE CONTROL OF CAMPYLOBACTER AND SALMONELLA IN CHICKEN MEAT (CXG 78-2011)*

1. Purpose and Scope of the Standard

The purpose of the work is to revise and update the *Guidelines on the Application of General Principles of Food Hygiene to the control of pathogenic Salmonella and Campylobacter in chicken meat* (CXG 78-2011). The revision will provide risk management options based on the latest scientific advice from FAO/WHO and will incorporate relevant aspects of the latest revision of the *General Principles of Food Hygiene* (CXG 1-1969).

The intended scope of the guidelines will not be changed from the original guidelines.

2. Relevance and Timeliness

At the request of CCFH, FAO/WHO through JEMRA brought together two expert panels to provide scientific advice on *Campylobacter* and *Salmonella* in chicken meat (on September 12-16, 2022 and February 6-10, 2023 respectively) and noted several critical developments in the last decade. These include:

Campylobacter

- Biosecurity and production management approaches that employ multiple good production practices, such as hygiene practices and sanitation, that can enhance control of *Campylobacter* in meat chickens.
- Incorporating risk mitigation measures for *Campylobacter* contamination at primary production sites, including partial depopulation, litter management, down period length, proximity to other livestock, and slaughter age.
- Feed and water additives such as short chain fatty acids, peroxyacetic acid (PAA), and caprylic acid.
- Review of processing interventions to include processing effects and pre-harvest interventions designed to reduce the pathogen load on incoming flocks.
- Review interventions such as carcass chilling or freezing to reduce *Campylobacter* loads in broiler chickens.

Salmonella

- Guidelines should be updated to include controlled access to breeding flocks, recognizing the heightened risk factors of access and the downstream impacts of flocks contaminated with *Salmonella.* Clarification of the use of cleaning compounds and disinfectants as Good Hygienic Practices (GHP), are recommended. Economic incentives can promote adoption of GHP and should be part of an updated Codex document.
- Updated guidelines for the control of *Salmonella* in raw poultry include discussions about using quantitative data to evaluate process controls during the farm to fork journey, and there is an additional need to hone testing paradigms to look more closely for pathogens of public health concern to ensure public safety. More work is needed to improve available technology and scientific applications before these techniques can be implemented. A review of interventions and their role in preventing contamination is needed, which will include a response to recent reports of salmonellosis from consumption of poultry liver and *Salmonella* infection that leads to osteomyelitis.
- More research is still needed to produce commercially available vaccines that do not negatively impact lifespan of chickens or the time-to-entry for broiler slaughter and processing.

3. Main aspects to be covered

The new work is intended to update the *Guidelines for the Control of Campylobacter and Salmonella in Chicken Meat* based on the latest scientific information, and to incorporate relevant aspects of the *General Principles and Food Hygiene* (CXG 1-1969) (revised in 2022). The guidelines will provide guidance on selection of the most appropriate risk management options and risk management tools.

The new work will consider factors relevant to the control of *Campylobacter* and *Salmonella,* including:

- The need for pre-harvest interventions to reduce pathogen load prior to harvesting, to address the risk of horizontal and vertical transmission, and recent reports of disease associated with organ meat which can be addressed by implementing controls during flock rearing.
- practical interventions that can be used to reduce foodborne illness risks associated with the consumption of

poultry meat, include preharvest intervention e.g., feed treatment, and post-harvest treatments, e.g. antimicrobial or organic acid drip interventions

- microbiological monitoring methods, particularly molecular-based process control and monitoring approaches
- recently available scientific data, in particular information on new pathogenic strains and their geographical spread and clinical incidence
- methods for the detection and characterization of pathogens by serotype and eventually by virulence-associated loci

4. An assessment against the *Criteria for the Establishment of Work Priorities*

General Criterion

Consumer protection from the point of view of health, food safety, ensuring fair practices in the food trade and taking into account the identified needs of developing countries

The proposed new work will support competent authorities and food business operators to implement practical interventions that can be used to reduce risk of campylobacteriosis and salmonellosis.

Criteria applicable to general subjects

(a) Diversification of national legislations and apparent resultant or potential impediments to international trade.

The revised CXG 78-2011 can aid countries in adopting practices to mitigate the risk of pathogenic *Salmonella* and *Campylobacter* in chicken meat, promoting international fair trade practices.

(c) Work already undertaken by other international organizations in this field and/or suggested by the relevant international intergovernmental body(ies).

Codex has already undertaken risk management work on *Campylobacter* and *Salmonella* in meat chickens.

(e) Consideration of the global magnitude of the problem or issue.

There is some evidence for increasing rates of illness associated with *Campylobacter* and *Salmonella* strains. Codex guidance is an essential contribution to reducing the global public health burden of campylobacteriosis and salmonellosis.

5. Relevance to the Codex strategic objectives

The proposed work is directly related to the purposes of the Codex Alimentarius Commission. Namely, goals one of the Codex Strategic Plan 2020-2025, to “Address current, emerging and critical issues in a timely manner” In particular, this work is relevant to Strategic Objective 1.2 “Prioritize needs and emerging issues” where the outcome is a “Timely Codex response to emerging issues and the needs of members”. This work will address the gap in guidance in particular in light of new information provided by JEMRA.

6. Information on the relation between the proposal and other existing Codex documents as well as other ongoing work

The revision of specific guidance on pathogenic *Campylobacter* and *Salmonella in chicken meat* will complement existing CCFH texts. This includes the *General Principles of Food Hygiene* (CXG 1-1969).

7. Identification of any requirement for and availability of expert scientific advice

CCFH made a request for expert scientific advice and two JEMRA meetings were created and reports are in final stages of completion. But during revision, CCFH may need additional scientific advice to validate proposed intervention language.

8. Identification of any need for technical input to the standard from external bodies so that this can be planned for

Not required at this time.

9. Proposed timeline for completion of the new work, including the start date, the proposed date for adoption at Step 5, and the proposed date for adoption by the Commission; the time frame for developing a standard should not normally exceed five years.

Subject to the Codex Alimentarius Commission approval at its 47th Session in 2024, it is hoped that the new work can be expedited (i.e. within two sessions of CCFH).