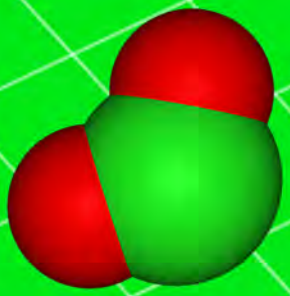

Benefits and Risks of the Use of Chlorine-containing Disinfectants in Food Production and Food Processing

Report of a Joint FAO/WHO Expert Meeting

Ann Arbor, MI, USA

27-30 May 2008

Food and Agriculture Organization of the United Nations

World Health Organization

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CONSULTATIONS AND WORKSHOPS

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WHO Library Cataloguing-in-Publication Data

Benefits and risks of the use of chlorine-containing disinfectants in food production and food processing: report of a joint FAO/WHO expert meeting, Ann Arbor, MI, USA, 27–30 May 2008.

1.Food contamination. 2.Chlorine - toxicity. 3.Disinfectants - toxicity. 4.Disinfection - utilization. 5.Food hygiene - standards. 6.Risk assessment. I.World Health Organization. II.Food and Agriculture Organization of the United Nations.

ISBN 978 92 4 159894 1 (NLM classification: WA 701)
ISBN 978 92 5 106476 4

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Printed by the WHO Document Production Services, Geneva, Switzerland

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ACKNOWLEDGEMENTS

The World Health Organization and the Food and Agriculture Organization of the United Nations gratefully acknowledge the contributions of the participants at the expert meeting (listed in Annex 1) as well as the authors of the individual chapters of this report (listed in Annex 2).

EXECUTIVE SUMMARY

Background

The Joint Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (WHO) expert meeting on the use of chlorine-containing disinfectants[1] in food production and food processing was held on 27–30 May 2008 in Ann Arbor, Michigan, United States of America. The meeting was supported by NSF International, WHO Collaborating Centre for Food and Water Safety and Indoor Environment.

The meeting was organized to provide scientific advice in response to a request made by the Codex Alimentarius Commission based on proposed terms of reference prepared by the thirty-seventh session of the Codex Committee on Food Additives and Contaminants and the thirty-seventh session of the Codex Committee on Food Hygiene on the safety and benefits of the use of "active chlorine" in food processing.

The primary intended benefits of disinfection processes are the reduction of microbial foodborne disease risk and the reduction of spoilage by control of contamination by pathogenic and non-pathogenic microorganisms. Control can be through direct treatment of foods and through management of cross-contamination from processing water and food contact surfaces. Disinfection treatment may lead to residues of disinfectants and disinfection by-products, which need to be considered in a risk–benefit assessment. The control of spoilage bacteria by disinfection, which increases the shelf life and stability of foods, was not considered by the expert meeting, as it has no direct impact on health risks.

Results

The expert meeting considered all available data related to the benefits and risks for human health of the use of disinfection processes in the food production and food processing industry. Emphasis was placed on chlorine-containing compounds, but alternative substances and methods used for disinfection of food and food contact surfaces were also considered.

The main goal of the meeting was to compare the health risk of chemical residues in food products following disinfection during food production and processing (including handling) with the benefit of lowering the risk of microbial hazards. The efficacy of chlorine treatment was considered, taking into account different treatment scenarios, different chlorine-containing substances and different combinations of pathogens and food commodities. These considerations focused on the most common current practices in various food sectors, as well as taking into account certain proposed new practices. Consideration was given to the efficacy and feasibility of potential alternative treatments to replace chlorine use. Unintended consequences, such as the potential for development of tolerance to microorganisms and effects on nutritional and organoleptic qualities, were also reviewed.

The main categories considered in food production and processing (including handling) were:

- meat and poultry;

[1] Chlorine-containing disinfectants include hypochlorous acid and its conjugate base, hypochlorite ion; chlorous acid and its conjugate base, chlorite ion; chlorine gas; and chlorine dioxide. Chloramines, chloramine-T and dichloroisocyanurate were included only where of relevance to the food processing industry.

- fish and fishery products;
- fresh produce (including hydroponics and sprouts);
- food contact surfaces.

Previous work and assessments carried out on national/regional and international levels formed the primary basis for the assessment, but additional information submitted in response to an open call for information was considered, as well as publicly available scientific studies and other information.

The approach taken was to identify the most common disinfection practices for the food categories described above; identify possible chemical residues in foods resulting from these treatments; estimate dietary exposure to these residues; estimate the potential risk to health from exposure to these chemical residues in foods; evaluate the efficacy of treatment in reducing the prevalence and numbers of pathogenic microorganisms on food; and estimate the potential resulting decreased health risk. The strength of the evidence was evaluated in all cases. Potential health risk from chemical exposure was then compared with the potential benefits of decreased health risk from reduced pathogen exposure in a systematic and stepwise approach.

A number of key use scenarios for each food category were described. Sodium hypochlorite is the most widely used disinfectant, in particular in the production and processing of poultry meat, leafy greens, sprouts, hydroponics and seafood, whereas its use in red meat processing is less common. Acidified sodium chlorite solutions are commonly used as an alternative to sodium hypochlorite in specific poultry processing steps. The use of chlorine-containing compounds in the fish and fishery products industry is focused mainly on disinfection prior to distribution, and the use on edible portions of fish and shellfish is limited. Non-chlorine-based chemical alternatives included peroxyacetic acid in poultry production and organic acids in meat production. Physical treatments were not considered.

A number of chlorine-containing disinfectants and their disinfection by-products as well as disinfectant alternatives can lead to residues in foods and hence to possible health risk. The toxicology of these substances was reviewed and compared with estimated dietary intakes. The identified residues of chlorine-containing disinfectants and disinfection by-products did not raise health concerns based on estimated dietary exposures. However, the evidence for health concerns associated with hypochlorite use in poultry, fish and shellfish was weak, owing to a lack of qualitative and quantitative information on the formation and presence of trihalomethanes (which are disinfection by-products) on the food. It was noted that although generally conservative estimates were used, there was a high degree of uncertainty in the dietary exposure assessments, as data on by-products were available primarily for drinking-water, and these data would have limited applicability to food. However, chlorine-containing chemicals are unstable, and it was concluded that there is a low potential for the presence of by-products in foods as consumed.

Microbiological risk assessments were performed for the key use scenarios, based on available studies and available risk assessments. It was concluded that the antimicrobial effects of disinfectants in food production may be overestimated by a lack of industrial-scale studies and a lack of inclusion of controls for the physical effects of water alone. In contrast, the effects may be underestimated by studying processes in isolation in industries where disinfectants have already been applied in previous steps. There was evidence for a reduction of pathogens on poultry carcasses and red meats by application of acidified sodium chlorite and chlorine dioxide and in smoked fish by application of sodium hypochlorite. There was also evidence that no pathogen reduction is achieved by application of sodium hypochlorite on poultry carcasses and red meats. Limited data provided evidence for reduction of cross-contamination by the application of disinfectants (in particular, sodium hypochlorite) in wash

and flume waters. Effective disinfection of food contact surfaces is an important means of reducing human exposure to pathogens in food.

Regarding unintended consequences of disinfection practices, the changes in nutrient content are low relative to the normal dietary intake of these nutrients. There is also no evidence to indicate that the use of chlorine-containing disinfectants and their alternatives is associated with acquired antimicrobial resistance to therapeutic agents.

Risk–benefit assessment integrates the results of two separate activities, risk assessment and benefit assessment, which can be done in a qualitative or quantitative way. Owing to a lack of data that would allow a quantitative assessment, the meeting developed a stepwise approach to risk–benefit assessment of chlorine-containing disinfectants and other alternatives to allow for a systematic comparison in a qualitative manner. Where scientific data were available, an assessment of risk and/or benefit was undertaken. The meeting categorized the use scenarios per food commodity in one of the following four categories:

1) No health concern identified; no benefits identified.
2) No health concern identified; benefits identified.
3) Health concern identified; no benefits identified.
4) Health concern identified; benefits identified.

The meeting identified several disinfectant use scenarios where there were no health concerns identified but for which there was a benefit. Only use scenarios for which it was concluded that there are both health concerns and benefits were considered to need further evaluation. However, the meeting did not identify any use scenarios that were of this type (i.e. both health concerns and benefits identified). The level of evidence supporting these conclusions as well as the uncertainties are discussed in the report.

Recommendations

The meeting identified important gaps in the available data. These data gaps constrained the scope of the risk–benefit assessments. Consequently, the meeting agreed on a number of recommendations for further scientific studies and the development of standardized practices.

The meeting emphasized that disinfectant treatment of water used in food processing must not be used to mask poor hygienic practices. The meeting recommended that disinfectants be used within the framework of good hygienic practice, with a system based on hazard analysis and critical control points where applicable and with adequate process controls in place.

INTRODUCTION

The Joint Food and Agriculture Organization of the United Nations (FAO)/World Health Organization (WHO) expert meeting on the use of chlorine-containing disinfectants[1] in food production and food processing was held on 27–30 May 2008 in Ann Arbor, Michigan, United States of America, at NSF International, WHO Collaborating Centre for Food and Water Safety and Indoor Environment.

The meeting was organized to provide scientific advice in response to a request made by the Codex Alimentarius Commission (FAO/WHO, 2006) based on proposed terms of reference prepared by the thirty-seventh session of the Codex Committee on Food Additives and Contaminants (FAO/WHO, 2005a) and the thirty-seventh session of the Codex Committee on Food Hygiene (FAO/WHO, 2005b) on the safety and benefits of the use of "active chlorine" in food processing.

The primary intended benefit of disinfection processes is the reduction of foodborne disease risk by control of contamination by pathogenic and non-pathogenic microorganisms through the direct treatment of foods and the elimination or management of cross-contamination from processing water and food contact surfaces. Such treatment may lead to residues of chemical by-products, which need to be considered in a risk–benefit assessment.

The expert meeting considered all available data related to the benefits and risks for human health associated with the use of disinfectants in the food production and food processing industry. Emphasis was placed on chlorine-containing compounds, but alternative substances and methods used for disinfection of food and food contact surfaces were also considered.

The main goal of the meeting was to compare the health risk of chemical residues in food products following the use of chlorine for disinfection purposes during food production and processing (including handling) with the benefit of lowering the risk of microbial hazards, taking into consideration the relevance and feasibility of potential alternative approaches (i.e. to replace chlorine use). The efficacy of chlorine treatment was considered, taking into account different treatment scenarios, different chlorine-containing substances and different combinations of pathogens and food commodities. These considerations were based on current practices in various food sectors, as well as taking into account certain proposed new practices. Unintended consequences, such as the potential for development of tolerance to microorganisms and effects on nutritional and organoleptic qualities, were also reviewed.

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response to an open call for information was considered, as well as publicly available scientific studies and other information.

The experts invited to the meeting had expertise in many different disciplines essential for the complex topic of the assessment of the benefits and risks of the use of disinfectants in food production and food processing: food technology and food processing, chemistry, food microbiology, toxicology, dietary exposure assessment, epidemiology and risk–benefit assessment in the field of diet and human health. The list of invited experts is provided in Annex 1. Professor Gabriel Adegoke, Mr John Fawell, Dr Emma Hartnett, Dr Jean-Charles Leblanc, Professor Mark Nieuwenhuijsen and Mr Alan Reilly were not able to participate in the meeting.

Declaration of interests

The participating experts completed the WHO form on Declaration of Interests and a confidentiality undertaking. Mr Scott L. Burnett and Dr Michael Graz declared interests, as they are or had recently been employed by a relevant industry. The meeting considered that this could constitute a potential conflict of interest. It was decided that the expertise of Mr Burnett and Dr Graz would be very valuable for the discussion on the current uses of disinfectants, but that they could not participate in the discussion and decisions regarding conclusions and recommendations of the meeting. These participants therefore left the meeting at that point.

Preparatory work

FAO and WHO issued an open call for experts and data in March 2007. In consideration of the complexity of the request for scientific advice, it was decided to invite a core group of experts with expertise in the various areas to be covered to a meeting, held at the FAO Headquarters in Rome, Italy, on 7–9 November 2007. The invited members of the core group were Dr Bassam Annous, Dr Diane Benford, Dr Joseph Cotruvo, Dr Steve Crossley, Dr Joseph Frank, Dr Arie Havelaar, Professor Mark Nieuwhuijsen, Mr Alan Reilly and Dr Inger-Lise Steffensen. The aim of this core group meeting was to provide input on the scope of the project, to outline and prepare the background documentation for the expert meeting and to identity potential experts for the drafting of these documents. The core group of experts also served as coordinators for the preparatory work for this expert meeting. The following outline of the background documentation was agreed to, and this outline was also followed in the report from this meeting:

- Chapter 1. Description of current processes
- Chapter 2. Chemistry of the compounds used
- Chapter 3. Chemical risk assessment
  - Toxicology and exposure assessment
  - Epidemiology
- Chapter 4. Microbiological risk assessment
- Chapter 5. Unintended consequences
- Chapter 6. Risk–benefit assessment
- Chapter 7. Conclusions and recommendations

The list of drafting experts is provided in Annex 2. FAO and WHO decided that it was not necessary to invite some of the experts drafting parts of the background document on current uses.

Definitions for the purpose of this meeting

For the purpose of this meeting, the following definitions were adopted:

- *Disinfectants*: Substances used in aqueous solutions in food production and processing to eliminate or reduce the number of microorganisms on the food in washing, chilling and other processes. In some countries, a distinction is made between disinfection and sanitization, but for the purpose of this document, no such distinction is made.

- *Disinfection by-products*: Chemical compounds formed during disinfection processes, other than the original substances introduced in the aqueous solution used for disinfection.

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