CONSULTATIONS AND WORKSHOPS

Health Implications of Acrylamide in Food

Report of a Joint FAO/WHO Consultation
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FOOD SAFETY PROGRAMME
DEPARTMENT OF PROTECTION OF THE HUMAN ENVIRONMENT
WORLD HEALTH ORGANIZATION

CONTENTS

EXECUTIVE SUMMARY

The FAO/WHO Consultation on Health Implications of Acrylamide in Food has undertaken a preliminary evaluation of new and existing data and research on acrylamide. The following main conclusions were reached:

Methods of analysis for acrylamide

By current standards of analytical science, the recent findings of acrylamide in foodstuffs are reliable. None of the methods used to measure acrylamide in foodstuffs has yet been fully validated by inter-laboratory collaborative trials. However, most methods fulfil the requirements of single-laboratory ("in-house") validation and accreditation.

Formation and fate of acrylamide in food

Acrylamide has been found in certain foods that have been cooked and processed at high temperatures, and the levels of acrylamide increase with the time of heating. However, the mechanisms of formation of acrylamide in food are poorly understood.

Exposure assessment

Based on the available data, food is estimated to make a significant contribution to total exposure of the general public to acrylamide. Average intakes for the general population were estimated to be in the range of 0.3 to 0.8 microgram of acrylamide intake per kilogram of body weight per day. Within a population, it is anticipated that children will generally have intakes that are two to three times those of adults when expressed on a body weight basis. Dietary intakes of acrylamide by some consumers may be several times higher than the average.

Non-cancer toxicology

Neurotoxicity is the key non-cancer, non-genotoxic effect of acrylamide in humans and animals. No neurotoxic effects are to be expected from the levels of acrylamide encountered in food.

Genotoxicity

Acrylamide may induce heritable damage.

Carcinogenicity

Acrylamide has a carcinogenic potency in rats that is similar to that of other carcinogens in food, but the intake levels for acrylamide are likely to be higher. For humans, the relative potencies of cancer-causing agents in food are not known. Only limited human population data are available for acrylamide and these provide no evidence of cancer risk from occupational exposure. All such studies have limited power to detect small increases in tumour incidence. The Consultation recognized the presence of acrylamide in food as a major concern in humans based on the ability to induce cancer and heritable mutations in laboratory animals.

Need for further information and provision of interim advice

The Consultation provided a range of recommendations for further information and new studies to better understand the risk to human health posed by acrylamide in food. The Consultation also provided some advice to minimize whatever risk exists, including avoiding excessive cooking of food[*], choosing healthy eating, investigating possibilities for reducing levels of acrylamide in food, and establishing an international network on acrylamide in food.

[*] However, all food – particularly meat and meat products – should be cooked thoroughly to destroy foodborne pathogens.

1. BACKGROUND

In April 2002 the Swedish National Food Administration (NFA) and researchers from Stockholm University announced their findings that acrylamide, a toxic and potentially cancer-causing chemical, is formed in many types of food prepared/cooked at high temperatures. The NFA informed regional and international authorities and organizations about their findings in order to initiate international collaboration as a priority. Moreover, international initiatives to commence multidisciplinary research were viewed as urgently needed as the formation of acrylamide during the cooking process was likely to be a general phenomenon.

In light of concern expressed by member countries, a Consultation was convened jointly by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO). The Consultation was held at WHO Headquarters in Geneva, Switzerland on 25-27 June 2002. A list of participants and agenda as adopted are provided in Annexes 1 and 2, respectively. Dr Dieter Arnold, Acting Director, Federal Institute for Health Protection of Consumers and Veterinary Medicine, Berlin, Germany served as Chairman. Dr Marvin Friedman, an expert in the field of acrylamide toxicity, who had worked for the acrylamide industry, did not participate in those sessions where the conclusions and recommendations were agreed. This course of action was agreed on, with WHO, prior to the Consultation.

The Consultation was opened by Dr David Nabarro, Executive Director of the Cluster on Sustainable Development and Healthy Environments and Senior Policy Adviser to the WHO Director-General. Dr Nabarro emphasized that in addition to the evaluation of specific scientific aspects of acrylamide in food, governments, industry and consumers were looking forward to any interim advice that could be offered, particularly in the light of the paucity of adequate data and the limited understanding of many of the processes involved.

2. OBJECTIVES OF THE CONSULTATION

The objectives of the Consultation were:

1. To review and evaluate new and existing data and research on acrylamide relevant to:

- toxicology, especially carcinogenicity and neurotoxicity;
- epidemiology;
- exposure assessment;
- analytical methodology; and
- formation, fate and bioavailability of acrylamide in cooked food.

2. To identify needs for further information and studies; and

3. To develop and suggest possible interim advice for governments, industry and consumers.

The Consultation reviewed the health significance of the presence of acrylamide in foods on the basis of known international assessment reports, specific background papers prepared in advance by invited experts and on the available new data and publications.

A list of the major documents available to the Consultation is provided in Annex 3. Note that individual documents are not specifically referred to in these texts, nor are they exhaustively summarized in this report. A list of abbreviations used in this report is at Annex 4.

3. METHODS OF ANALYSIS

3.1 Introduction

The Consultation reviewed the methods of analysis available to test for acrylamide in foodstuffs and food ingredients, and for acrylamide and its metabolites as haemoglobin adducts in blood.

3.2. Foodstuffs and food ingredients

3.2.1. Sampling

Levels of acrylamide can vary considerably in foods, seemingly due to the processing or cooking conditions used and the temperature achieved. Consequently, there can be considerable variability from product to product and even concentration hot-spots within an individual food item. The whole food item or package should be homogenized before sub-sampling and a representative portion taken for analysis. For the foodstuffs investigated to date, there have been no problems reported of significant losses during storage and homogenization of the sample prior to analysis.

3.2.2. Extraction

Free acrylamide is extracted from the sample using cold or hot water. It has been demonstrated, by adding known amounts of acrylamide standard to the sample before extraction, that these extraction procedures give complete recovery. Many sample extracts can be analysed directly, however some sample types benefit from further cleanup and concentration of the extract. It is desirable to add an internal standard to the food sample at the outset, as an internal standard compensates for any recovery losses in these steps and helps to ensure that results are reliable.

3.2.3. Gas chromatography/mass spectrometry (GC-MS)

Although acrylamide can be analyzed as such, without derivatization, when using GC-MS, the molecule is normally brominated to form a derivative that has improved GC properties. The acrylamide derivative is identified by its retention time and by the ratio of characteristic MS ions. Once the identity of acrylamide has been established in a particular type of food, it may be possible to use gas chromatography with electron capture detection (ECD) or other selective detection techniques to routinely monitor levels, although with this analytical technique the identification rests on the retention time alone. The lowest level that can be measured when using GC-MS is in the range of 5 to 10 μg/kg.

3.2.4. Liquid chromatography/tandem mass spectrometry (LC-MS/MS)

Because there had been concerns about possible artefact formation during the bromination procedure, LC-MS/MS methods were developed for the direct analysis of acrylamide without the need to derivatize. Identification of the substance is by its retention time and by the relative ion intensities. The limit of measurement using LC-MS/MS is about 20 to 50 µg/kg.

3.2.5 Identification of acrylamide

When the same food sample is extracted and analyzed by both methods described, there is generally excellent agreement between the results and the putative acrylamide fulfils the identification criteria in both techniques. This provides added confidence in the qualitative and quantitative results to date. By modern standards of analytical evidence, the identification of acrylamide in foodstuffs is highly reliable.

3.2.6. Data quality

None of the methods used to measure acrylamide in foodstuffs has been fully validated by interlaboratory collaborative trials. However, some methods fulfil the requirements of single-laboratory ("in-house") validation and accreditation. Additionally, some samples have been analyzed by different laboratories using the same method, or by one laboratory using different methods, and there has generally been good agreement. It is considered that the measurement uncertainty is small in relation to the large variability that appears to occur even between different batches of the same product. Therefore, there seems to be no reason at this time to reject any of the limited data available on acrylamide concentrations in foods, or to exclude these data from a preliminary assessment of exposure.

3.3 Determination of biomarkers of exposure

Acrylamide and its metabolite, glycidamide, react readily with a number of biomolecules including haemoglobin. GC-MS methods for the determination of the adducts of acrylamide and glycidamide with haemoglobin have been reported. The sensitivity of these GC-MS methods is such that the adducts can be measured at concentrations in the blood that are relevant to possible dietary exposure to acrylamide. Consequently, the adducts can be used as biomarkers of exposure. In fact, it was the observation of unexplained levels of haemoglobin adducts that gave the first clue that there may be an unknown source of exposure, now generally agreed to be acrylamide in heated foods. The biomarker adducts can give a time-