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Acrylamide in Food

The aim of this document is to provide food business operators (FBOs), enforcement officers and other stakeholders with a concise overview of the health hazards of, and sources of dietary exposure to, acrylamide in food. It provides guidance for FBOs on their legal obligations and risk management measures to reduce levels of acrylamide in food and also a bibliography giving sources of further information. The summary below gives a short synopsis of the information, while the following pages provide more technical detail.

Summary

Acrylamide is an industrial chemical used in the manufacture of polyacrylamides, and has also been detected in a wide range of foodstuffs at relatively high concentrations. It is formed during the frying, roasting or baking of a variety of foods, particularly starchy foods such as potatoes and cereal products. Food scientists worldwide have been concerned about the presence of acrylamide in food, because of its toxicity. The main concern regarding possible health effects of acrylamide in food has been its carcinogenicity and genotoxicity (DNA-damaging effects). It causes tumours in laboratory rats, although there is no definitive evidence that exposure to acrylamide in food causes cancer in humans. It has also been shown to be neurotoxic in humans and may affect reproductive processes. A number of national and international agencies have carried out risk assessments on acrylamide in food and have concluded that efforts should be made to reduce levels to as low as possible.

Acrylamide has been found in a wide variety of fried, baked or roasted foods; it is found in both foods processed by manufacturers and foods that are cooked in the home. Acrylamide is most prevalent in fried potato products (such as French fries (chips) and potato crisps), cereals, crispbreads, biscuits and other bakery wares, and coffee. No specific maximum limits (MLs) for acrylamide in food have as yet been introduced in the European Union or elsewhere in the world. Rather, the onus has been placed on manufacturers to observe the ALARA principle (As Low As Reasonably Achievable), by developing measures to reduce the levels of acrylamide in their products. Reflecting their responsibilities under the General Food Law, Directive 178/2002, to supply safe food, it is important that FBOs identify critical control points (CCPs) in their processes leading to the formation of acrylamide in their products; this will enable them to develop and apply proper HACCP systems which will ensure that levels of acrylamide are as low as possible.

Methods adopted by the manufacturing industry worldwide together with research undertaken by food technologists have identified some measures to control acrylamide formation and hence to reduce the levels in food. The European Commission has issued guidance on such measures to manufacturers, retailers, caterers and consumers, summarised in the Appendix to this document. The CIAA (European Food and Drink Confederation) has also published a "Toolbox", which provides a strategy for minimising the acrylamide content of manufactured food products. Additionally, CIAA and the European Commission in collaboration with national authorities have developed Acrylamide Pamphlets for five key manufacturing sectors: biscuits, crackers and crispbreads, bread products, breakfast cereals and fried potato products such as potato crisps and French fries, in order to assist small and medium enterprises (SMEs) in the implementation of the "Toolbox".

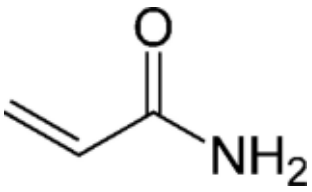
This document provides references to the European Commission and other international guidance and to the CIAA Toolbox and information pamphlets for SMEs.

Acrylamide in Food

Food Safety AUTHORITY OF IRELAND

1. Introduction

Acrylamide is an industrial chemical used in the manufacture of polyacrylamides, which have applications in water treatment and mining, in grouting agents, as a laboratory reagent and in cosmetics. It has this structure:



In 2002, Swedish scientists and the Swedish National Food Authority reported the existence of acrylamide in a variety of fried and baked foods, in particular in potato products such as chips. This finding has since been confirmed by many other food scientists throughout the world. Research into acrylamide in food shows that the chemical is formed during the frying, roasting or baking of a variety of foods, particularly starchy foods such as potatoes and cereal products, as a side product of the Maillard reaction.

The Maillard reaction is a term used to describe the complex chemical reactions occurring during processes such as frying and roasting, which largely determines the colour, flavour and texture of cooked foods. The amino acid asparagine and reducing sugars such as glucose and fructose are key constituents of foods initiating the Maillard reaction and thus giving rise to high levels of acrylamide. The unexpected discovery of acrylamide in food attracted the attention of food scientists worldwide because of its toxicity.

2. Toxicity of acrylamide

The main concern regarding possible health effects of acrylamide in food is its carcinogenicity and genotoxicity (DNA-damaging effects). It causes tumours in laboratory rats, and since its discovery in food, detailed studies have been carried out to establish whether it causes cancer in humans, but as yet there is no definitive evidence that this is the case. However, it is classified by the International Agency for Research into Cancer (IARC) as a probable human carcinogen. It has also been shown to be neurotoxic in humans and may affect reproductive processes. The risks to the health of consumers of acrylamide in food have been assessed by many international bodies including the European Food Safety Authority, the Food and Agriculture Organization (FAO) of the United Nations and the World Health Organization (WHO). Given the toxicity of acrylamide, these bodies have all concluded that efforts should be made to reduce acrylamide concentrations in food.

3. Exposure to acrylamide

Acrylamide has been found in a wide variety of fried, baked or roasted foods; it is found in both foods processed by manufacturers and foods that are cooked in the home. Although the presence of acrylamide in food has been discovered comparatively recently, it has probably been present for many years, in staple foods forming a significant part of the human diet. Acrylamide has not been found in foods that are not fried or baked, such as boiled potatoes.

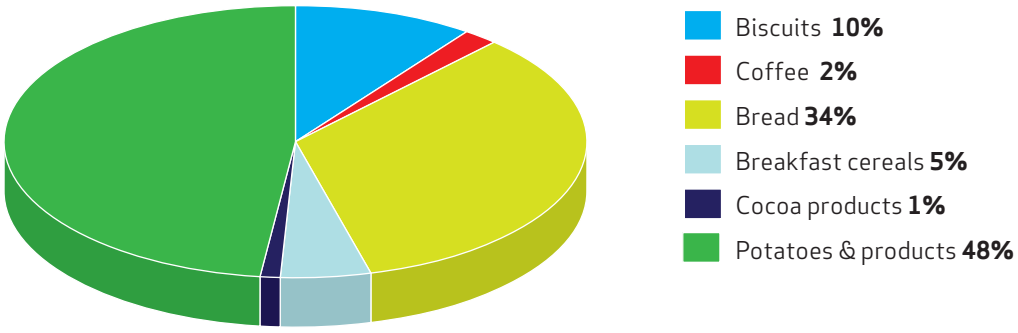
Several large databases of acrylamide occurrence data have been compiled, including the European Union's acrylamide monitoring database, the United States Food and Drugs Administration's acrylamide survey data and the WHO's Summary Information and Global Health Trends database for acrylamide. All these databases show that acrylamide is most prevalent in fried potato products (such as French fries (chips) and potato crisps), cereals, crispbreads, biscuits and other bakery wares, and coffee.

Acrylamide in Food

The mean dietary exposure to acrylamide has been estimated by the Food Safety Authority of Ireland (FSAI) to be approximately 0.6 microgram (µg) per kg body weight per day for the Irish adult population, with high-level consumers being exposed to approximately 1.75 µg/kg bw/day. These estimates of exposure of Irish consumers to acrylamide compare well to exposure estimates reported by the Joint FAO/WHO Expert Committee on Food Additives (JECFA), which ranged from 0.3 to 2.0 µg/kg bw/day for mean consumers and 0.6 to 3.5 µg/kg bw/day for high-level consumers. The FSAI exposure analysis confirmed that consumption of potatoes and potato products provides the largest contribution to dietary intake of acrylamide followed by consumption of bread and biscuits, although coffee is also a contributor to exposure, as shown in the following Figure.

Contribution to acrylamide intake from selected food groups for the Irish adult population

% Contribution to mean µg/kg bw AA exposure (total population)



4. Sampling and analysis

The European Commission has made a Recommendation to Member States (2007/331/EC) in 2007 on the monitoring of acrylamide levels in food. This Recommendation provides guidelines for sampling and analysis and indicates that the sampling procedures laid down in Regulation 333/2007 for the official control of the levels of lead, cadmium, mercury, inorganic tin, 3-MCPD and benzo(a)-pyrene in foodstuffs should be followed, in order to ensure that the samples taken for analysis are representative of the entire foodstuff. Methods for the analysis of acrylamide in food are based either on GC-MS or on HPLC-MS-MS. Different sample preparation methods are used dependent on the food matrix to be analysed, with matrices such as potato chips, French fries, cereals, bread, and roasted coffee providing more reproducible results than difficult matrices such as soluble coffee, cocoa, molasses, or malt.

5. Legislation

No specific MLs for acrylamide in food have as yet been introduced in the European Union or elsewhere in the world, although there have been extensive discussions regarding this aspect. In Germany, a minimisation concept was introduced in 2002, based on a classification of foodstuffs into defined commodity groups. In each commodity group, a 'signal value' was established which was defined as the lowest acrylamide level found in the top 10% of foods within a commodity group. In no case could the signal value be set at a level greater than 1,000 micrograms per kilogram of foodstuff, and signal values, once set for a particular commodity, could not be raised. This strategy has been successful in lowering acrylamide levels in key foodstuffs. The German initiative has not been followed elsewhere in Europe, rather, the onus has been placed on manufacturers to observe the ALARA principle by developing measures to reduce the levels of acrylamide in their products (see "Toolbox" in section 6).

Acrylamide in Food

6. Hazard Analysis Critical Control Points (HACCP) and other control measures for acrylamide in food

The mechanism of formation of acrylamide in food and factors contributing to its formation are now reasonably well understood. Formation of acrylamide commences simultaneously with the Maillard reaction (see Introduction, section 1), peaking with the desired browning coloration of the cooked product, e.g. chips, biscuits, bread, and it is virtually impossible to prevent formation. However, methods adopted by manufacturing industry worldwide together with research undertaken by food technologists have identified the CCPs for acrylamide formation, and have led to the identification of some measures to control formation and hence to reduce the levels in food. Levels of asparagine and reducing sugars such as glucose and fructose in the food ingredients, e.g. in potatoes, are key determinants of ultimate levels of acrylamide in the cooked product, and are important points of control. Recently, treatment of raw ingredients with the enzyme asparaginase, which breaks down asparagine, has proved to be effective in reducing levels of acrylamide in food.

The European Commission has issued guidance on measures shown to be effective in mitigating acrylamide formation to manufacturers, retailers, caterers and consumers, following several workshops held with stakeholders to discuss the issue of acrylamide formation in food. These measures, summarised in the Appendix to this document, should be followed at all times. The Commission also provides a useful website on its initiatives on acrylamide.

http://ec.europa.eu/food/food/chemicalsafety/contaminants/acryl_guidance.pdf

The CIAA (European Food and Drink Confederation) have published a "Toolbox", which provides a strategy for minimising the acrylamide content of manufactured food products, addressing measures under 4 main areas: (1) Agronomical (2) Recipes (3) Processing (4) Final Preparation. Manufacturing industry are advised to follow the Toolbox closely in order to ensure the safety of the products they place on the market.

http://www.ciaa.be/documents/brochures/toolbox%20rev11%20nov%202007final.pdf

Additionally, the CIAA and the European Commission in collaboration with national authorities have developed *Acrylamide Pamphlets* for five key manufacturing sectors: biscuits, crackers and crispbreads, bread products, breakfast cereals and fried potato products such as potato crisps and French fries, in order to assist SMEs in the implementation of the "Toolbox". The pamphlets are available on the following website:

http://ec.europa.eu/food/food/chemicalsafety/contaminants/acrylamide_en.htm

7. Dietary advice

The advice from the FSAI is that consumers maintaining a healthy balanced diet, rich in fresh fruit and vegetables and low in fat, should not be unduly concerned about the presence of acrylamide in food, based on current knowledge. The FSAI does not consider that people should make major changes to their diet or stop eating any of the food products in which acrylamide has been reported. A large consumption of fried fatty foods such as chips and potato crisps should however be avoided, and foods should not be overcooked or over fried (for long periods and/or at high temperatures, above 120 degrees Celsius).

Acrylamide in Food

Food Safety AUTHORITY OF IRELAND

Biobliography

CIAA Acrylamide "Toolbox"
http://www.ciaa.be/documents/brochures/toolbox%20rev11%20nov%202007final.pdf

European Commission Recommendation of 3 May 2007 on the monitoring of acrylamide levels in food (2007/331/EC)
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:123:0033:0040:EN:PDF

European Commission Recommendation Information on Ways to Lower the Levels of Acrylamide Formed in Food
http://ec.europa.eu/food/food/chemicalsafety/contaminants/acryl_guidance.pdf

European Commission Website on acrylamide in food:
http://www.europa.eu.int/comm/food/food/chemicalsafety/contaminants/index_en.htm.

JECFA: Joint FAO/WHO Expert Committee on Food Additives: Evaluation of certain food contaminants. WHO Technical Report Series, No. 930 (2006)
http://www.who.int/ipcs/food/jecfa/summaries/summary_report_64_final.pdf

International Food Safety Authorities Network (INFOSAN) Information Note No. 2/2005:Acrylamide
http://www.who.int/foodsafety/fs_management/No_02_Acrylamide_Mar05_en_rev1.pdf

WHO Website specifically devoted to acrylamide:
http://www.who.int/foodsafety/chem/chemicals/acrylamide/en/index.html

Further information on acrylamide including responses to frequently asked questions and advice on storage of potatoes to minimise formation of reducing sugars is available on the FSAI Website.
http://www.fsai.ie/industry/hottopics/industry_topics_acrylamide.asp
http://www.fsai.ie/industry/hottopics/industry_topics_acrylamide_update.asp

Information is also available on the websites of the Swedish National Food Administration
www.slv.se/

and the UK Food Standards Agency website
http://www.food.gov.uk/safereating/chemsafe/acrylamide_branch/

Acrylamide in Food

Food Safety AUTHORITY OF IRELAND

Appendix

Information on Ways to Lower the Levels of Acrylamide Formed in Potato Products

To food producers and processors

1. Fried and baked cut potato products should be golden yellow and not browned.
2. Where appropriate, e.g. for potatoes destined for cutting and frying or baking, select potato varieties with low levels of reducing sugars.
3. For long term storage of potatoes destined for cutting and frying or baking avoid storage below 8°C whenever possible. For short term storage of potatoes, avoid storing below 8°C whenever possible. Investigate and optimise storage conditions to keep levels of reducing sugars low whilst avoiding sprouting or spoilage.
4. For conventionally-fried cut potato products, the frying temperature should not exceed 175°C.
5. Oven baking temperatures for cut potato products should not exceed 200°C for conventional ovens and should not exceed 190°C for fan-assisted ovens.
6. Where possible part-cook/blanch or soak cut potato products in water (and drain well) before frying or baking.
7. Avoid using glucose/dextrose or other sugar dips/coatings for products to be fried or oven baked whenever possible.
8. Part-cooked potato products should be labelled with instructions to cook until golden yellow and to avoid browning. Accurate cooking temperature/time instructions should be given to avoid too hot frying and baking temperatures.
9. Avoid excess browning of baked cereal products.
10. In bakery products use raising agents other than ammonium bicarbonate whenever possible and acceptable, e.g. sodium hydrogen carbonate.

To retailers

1. Avoid storing potatoes below 8°C where feasible and otherwise investigate alternative storage practices. Ideally store potatoes in the dark at a temperature of 8°C or slightly higher.
2. Investigate the feasibility of labelling potato varieties which are low in reducing sugars and most suitable for cutting and frying or baking.
3. Check that suppliers are aware of the above recommendations and where possible, follow them.

To caterers

1. Avoid storing potatoes below 8°C. Ideally store potatoes in the dark at a temperature of 8°C or slightly higher.
2. Fried and baked cut potato products should be golden yellow and not browned.
3. Where possible, blanch or soak cut potato products (and drain well) before frying or baking.
4. Frying temperatures for cut potato products should not exceed 175°C. Ensure temperature controls on fryers are reliable and accurate.
5. Oven baking temperatures for cut potato products should not exceed 200°C for conventional ovens and should not exceed 190°C for fan-assisted ovens.
6. Avoid excess browning of baked cereal products.
7. Follow up-to-date preparation instructions given by suppliers.

Acrylamide in Food

Food Safety AUTHORITY OF IRELAND

To consumers

1. Avoid storing potatoes below 8°C – do not store them in the refrigerator. Ideally, store potatoes in the dark at a temperature of 8°C or slightly higher.
2. Fried and baked cut potato products should be golden yellow and not browned.
3. Frying temperatures for cut potato products should not exceed 175°C.
4. Oven baking temperatures for cut potato products should not exceed 200°C for conventional ovens and should not exceed 190°C for fan-assisted ovens. For processed potato-based products follow the cooking instructions on the food packets.
5. Where possible, blanch or soak cut potato products (and drain well) before frying or baking. For pan-fried potatoes use already boiled potatoes rather than raw potatoes.
6. Avoid excess browning of baked cereal products.
7. Follow carefully the cooking instructions on food packets.