The HEATOX Workshop · Report

Heat-generated food toxicants - Identification, characterisation and risk minimisation

13-14 June 2006
Graz, Austria
The Heatox Workshop was planned and designed by a working group (all partners in the HEATOX project) consisting of:

- Kerstin Skog, coordinator HEATOX, University of Lund, Sweden
- Michael Murkovic, Technical University of Graz, Austria
- Barbara Gallani, The European Consumers’ Organisation, BEUC, Belgium
- Hans Lingnert, The Swedish Institute for Food and Biotechnology, Sweden
- Karl-Erik Hellenäs, National Food Administration, Sweden
- Leif Busk, National Food Administration, Sweden
- Marco Dalla Rosa, University of Bologna, Italy
- Helga Odden Reksnes, National Veterinary Institute, Norway
- Hanne Mari Jordsmyr, National Veterinary Institute, Norway

Many of the other participants were also engaged in the planning process. A special thank to Torbjörn Albert at the National Food Administration in Sweden for preparing the extensive background material for the working groups on home-cooking guidelines and to the students of the Technical University of Graz for all practical arrangements.

The HEATOX Workshop Report was compiled by Hanne Mari Jordsmyr and Helga Odden Reksnes. The report in electronic format can be downloaded from www.heatox.org. A printed version can be ordered from Hanne Mari Jordsmyr, National Veterinary Institute, P.O.Box 8156 Dep. 0033 Oslo, Norway. + 47 23 21 63 66, hanne-mari.jordsmyr@vetinst.no.
Dear reader,

Dialogue and interaction with stakeholders is an important part of the HEATOX risk communication strategy. The action plan has four stages;

1. Dialogue and interaction with identified stakeholders at their own arenas and through their proper channels.
2. HEATOX Workshop
3. Dialogue and interaction with identified stakeholders, evaluation of process and assessing communication objectives.
4. Production of end deliverables Guidelines to consumers on healthy homecooking and consumption of cooked foods (D59), Manual on strategies to industry and restaurants etc. to minimise acrylamide formation (D60) and Guidelines to Good Risk Communication Practice related to heat-induced toxicants (D61)

The HEATOX Workshop represents the second stage of the HEATOX risk communication action plan and the Workshop has gone further on actions already taken by key stakeholders, for example initiatives taken by the EU Commission, WHO/JECFA, other research projects, CIAA, BEUC etc.

The intention of the Workshop was to gather key persons representing consumer interests, authorities, industry and research to share relevant knowledge and discuss the state of the art of science and technology as well as challenges related to heat-generated food toxicants in general and Acrylamide in particular.

I hope this HEATOX Workshop report will contribute to the knowledge building and knowledge sharing process related to heat-generated food toxicants in general and Acrylamide in particular.

I would like to thank lecturers, chairs and rapporteurs as well as Aquarium discussants for sharing, organising and compiling knowledge and all participants at the workshop for contributing to the important interaction and dialogue between HEATOX scientists and key stakeholders.

November 2006,

Kerstin Skog
Coordinator HEATOX project
The HEATOX Workshop · Programme
Heat-generated food toxicants · Identification, characterisation and risk minimisation

Tuesday 13 June 2006 «The Risk - case Acrylamide»
Chair: Barbara Gallani

12:00  Lunch
13:15  Welcome  Kerstin Skog, HEATOX and
        Michael Murkovic, Faculty for Chemistry, Chemical- and
        Process Engineering, Biotechnology, TU Graz
13:30  Introduction  HEATOX approach to heat-generated food toxicants  Karl-Erik Hellenäs, HEATOX

Knowledge status AA  Exposure and reduction scenarios  Jacob van Klaveren, HEATOX

Minimisation options:
Industry  Hans Lingnert, HEATOX
Home-cooking  Kerstin Skog, HEATOX

14:40  Coffee-break
15:00  Consumer attitudes  Introduction  Barbara Gallani, BEUC


Risk perception and communication  General issues  Gene Rowe, Institute of Food Research, Norwich

16:00  Working groups
1. Home-cooking guidelines  Lauren Jackson/Anika De Mul
2. Home-cooking guidelines  Beate Kettlitz/Jonas Mojica-
   Lazaro and Pelle T. Olesen
3. Cultural differences  Sigrid Lauryssen/Thomas
   Bjellås
4. Industry strategies  Geoff Thompson/Jeroen Knol
   Eleni Alevritou/Arwa Mustafa
   and Erik Pettersson
5. Industry strategies

Summary  Chairs/rapporteurs

20:00  Dinner with Mozart
The HEATOX Workshop · Programme

Heat-generated food toxicants - Identification, characterisation and risk minimisation

Continued

Wednesday 14 June 2006 «The Risk Perspective»
Chair: Stuart Slorach
co-chair: Helga Odden Reksnes

Breakfast

09:00 Lecture The Acrylamide story Margareta Törnqvist, HEATOX

10:00 Aquarium*

   Putting risk from heat-generated food toxicants into context
   Topics to be discussed: toxicology, exposure, minimisation, risk and benefit, regulatory perspective, comparing risks, risk characterisation, communication, uncertainties, consumer education and consumer interests

   The Aquarium* group: Wendy Matthews, Angelika Tritscher, David Lineback, Gene Rowe, Barbara Gallani, Richard Stadler, Leif Busk, Jacob van Klaveren and Margareta Törnqvist

11:00 Coffee-break

11:20 Aquarium* continues

   Closing remarks

Stuart Slorach, National Food Administration, Sweden and Kerstin Skog, HEATOX

13:00 Lunch

* The expression Aquarium denotes a specially designed type of panel debate where key persons (stakeholders) are invited to discuss important issues, and the supporters of each discussant/stakeholder are put in a position, also physically, occupying a segment of the circle behind «their discussant» where they can advice, question and support «their» representative by oral or short written messages. The discussion, and to some degree, choice of topics are being moderated by a chairperson.

The idea is that the aquarium form allows a more «intelligent» and responsible dialogue than the discussion of the traditional panel form where often the different participants advocate only one aspect of an issue or are confronting each other with different opinions on the same issue without being responsible for reaching agreements or a mutually understood pattern of disagreement. Ideally a consensus statement or a negotiated platform should be produced in the end.
## HEATOX Workshop 13 – 14 June 2006

### List of participants:

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
<th>Country</th>
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<tr>
<td>Abrahamsson Zetterberg</td>
<td>National Food Administration</td>
<td>Sweden</td>
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<td>Albert</td>
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<td>Alevritou</td>
<td>EKPIZO - Consumers Association the quality of life</td>
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<td>Alexander</td>
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<td>Becalski</td>
<td>Health Canada, Food Research Division</td>
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<td>Dalla Rosa</td>
<td>Dept. of food science, University of Bologna</td>
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<td>De Mul</td>
<td>RIKILT - Institute of Food Safety</td>
<td>The Netherlands</td>
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<td>Frandsen</td>
<td>Danish Institute for Food and vet. Research</td>
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<td>Gallani</td>
<td>BEUC - The European Consumers’ Organisation</td>
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<td>Glatt</td>
<td>German Institute of Human Nutrition</td>
<td>Germany</td>
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<td>Grob</td>
<td>Official Food Control Authority of the Canton of Zurich</td>
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<td>Göbel</td>
<td>Federal Office of Consumer Protection and Food Safety</td>
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<td>Hubená</td>
<td>Consumers Defence Association of the Czech Republic</td>
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<td>Jackson</td>
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<td>Konings</td>
<td>Food and Consumer Product Safety Authority (VWA)</td>
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<td>Lalljé</td>
<td>Safety and Environmental Assurance Centre, Unilever (ILSI)</td>
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<td>Lineback</td>
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<td>Matthews</td>
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<td>Mojica-Lazarro</td>
<td>Department of Food Science, University of Leeds</td>
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<td>Samouris</td>
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<td>Lund University, Division of Food Engineering</td>
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<td>Spök</td>
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<td>Thompson</td>
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<td>Thornley</td>
<td>EMRA - European Modern Restaurant Association</td>
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<tr>
<td>Wenzl</td>
<td>Institute for Reference Materials and Measurements</td>
<td>Belgium</td>
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(H): Partner in HEATOX  
(H-ExP): Member of HEATOX External Panel
Project format

- Duration: 1 Nov 2003 to 28 Feb 2007
- Commission grant: 4.2 million euro
- 24 partners in 14 countries

Project aim

- Identify, characterize and minimize health risks from heat generated food toxicants

Project overview

- Formation
  - Household Cooking
  - Industrial Processing
- Exposure
  - External
  - Internal
- Hazard Characterisation
  - DNA damage
  - Non-genetic Damage
- Analysis
- Risk Assessment
- Management, Communication, Dissemination and Training
- Mutation, Cancer
- Fertility
- Neurological Effects
- Other Health Effects

Project approach

- Acrylamide in focus
  - but also other known and unknown heat-induced toxicants
    - risk-risk, risk-benefit
- Complementary to other research
  - fill important knowledge gaps
  - tasks where multi-disciplinary approach needed
- Communication
  - External advisory panel
  - Work-shops

Major project deliverables

- D37 Risk characterisation.
- D59 Guidelines to consumers on healthy home cooking and consumption of cooked foods.
- D60 Manual on strategies to food industries, restaurants, etc., to minimize acrylamide formation.
- D61 Guidelines to good risk communication practise related to heat induced toxicants.
Acrylamide formation

Asparagine + Sugar (glucose, fructose, ...) + Heat → Acrylamide

“Maillard reaction”

AA occurrence in food

- Fried and baked foods (>120°C)
- “Dry surface” phenomena - linked to browning
- Carbohydrate rich foods
  - Potato - high (<5000µg/kg)
  - Cereals - medium
  - Meat - low (<50µg/kg)

Critical formation factors

- Precursor availability
  - Limiting factor: Reducing sugars in potato, Asparagine in cereals
- Heating temperature and time (heat flux)
- Water activity
- pH

Acrylamide in different foods

<table>
<thead>
<tr>
<th>Food type</th>
<th>median</th>
<th>75% quartile</th>
<th>maximum</th>
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<tbody>
<tr>
<td>French fries</td>
<td>173</td>
<td>339</td>
<td>4653</td>
</tr>
<tr>
<td>Potato crisps</td>
<td>570</td>
<td>980</td>
<td>3770</td>
</tr>
<tr>
<td>Fine bakery ware</td>
<td>50</td>
<td>134</td>
<td>333</td>
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<tr>
<td>Crispbread</td>
<td>248</td>
<td>514</td>
<td>2838</td>
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<tr>
<td>Breakfast cereals</td>
<td>53</td>
<td>126</td>
<td>1540</td>
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<tr>
<td>Coffee roasted</td>
<td>285</td>
<td>387</td>
<td>112</td>
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Data from JRC-irmm data base
Introduction

- What is exposure assessment?
- Need for a harmonized approach?
- Are correlations between intake, biomarkers and effect good enough?
- Margin of Exposure (MoE)
- Is reduction of exposure to acrylamide possible and can we reach an acceptable MoE?
- Can we quantify possible side effects?

How to measure exposure

- Duplicate diet
- Calculation: \( \sum \text{residue} \times \text{food consumption} \)

Food Consumption

- Food record
- 24 hour recall
- Food frequency questionnaire

Monitoring of acrylamide concentrations

- Acrylamide has been analyzed in Europe in:
  - Austria, Belgium, Czech republic, Denmark, Finland, France, Germany, Ireland, Norway, Poland, Sweden, Switzerland, The Netherlands, United Kingdom
  - Most countries analyzed acrylamide in majority of foods from national market, some countries analyzed specifically foods high in acrylamide, new foods possibly containing acrylamide or studied different varieties.
  - Specially analyzed foods potato cultivars, breast milk, baby food, toasted bread

Source: EU Summary of activities
http://ec.europa.eu/food/food/chemicalsafety/contaminants/acryl_database_en.htm

Acrylamide concentration database

- Joint Research Centre (EU-database concentration)
- June 2006 update; contains 7150 checked values, 5800 with running z-scores
- Check reliability LOD and LOQ, and reported value relative to LOQ
- Calculation of running z-scores

Food frequency questionnaire

- how often: 1 month, 1 week, 2-3 week, 4-5 week, daily
- portion

Food category

- Snacks x
- salted snacks ?
- peanuts ?
- crisps ?
- brand x 
- brand y

- Long-term intake at the individual level
- Relative cheap and quick (mostly used in epidemiology)
- Not very accurate
- Limited in the number of questions (approx. 150)
- Limited in details
- Used for health item x, is most likely not very usable for health item y
Exposure percentiles as function of brand loyalty

IISI-paper review of intake within Europe
- Intake levels in several countries (chemical toxicology 43 363-410)
  - France mean exposure 0.40 µg per kg bw per day for adults 1.06 for children
  - The Netherlands average 0.98 µg per kg bw per day for children 1-6 years,
  - Sweden average 0.5 µg per kg bw per day for different age groups (Food Chem. Toxicol. 2003(41) 1581-6)
  - average 0.3-0.8 µg kg bw per day for long-term intake (WHO)
  - some consumers will be exposed to significant higher levels

Probabilistic exposure assessment

Processing studies done in Heatox
- Applied in laboratory setting, it is not known whether this is applicable in the future!
  - Bread Yeast leavened bread (infrared/impingement baking)
  - Coffee Variety, roasting time
  - French fries Shape, extended blanching time, time-temp combination in frying, storage conditions
  - Crisps Blanching, storage conditions, frying temperature

Reduction scenarios

<table>
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<tr>
<th>scenario</th>
<th>Original level</th>
<th>Reduction</th>
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<tbody>
<tr>
<td>Bread</td>
<td>-</td>
<td>70%</td>
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<tr>
<td>Coffee</td>
<td>200 µg/kg</td>
<td>30%</td>
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<tr>
<td>French fries</td>
<td>200 µg/kg</td>
<td>50% / 80%</td>
</tr>
<tr>
<td>Crisps</td>
<td>1000 µg/kg</td>
<td>200ng/g and 60 ng/g</td>
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Margin of Exposure concept

Calculation of the Margin of Exposure (MoE) (MoE = effect level / intake level)

<table>
<thead>
<tr>
<th>person intake</th>
<th>CED/BMDL</th>
<th>MoE</th>
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<tbody>
<tr>
<td>James</td>
<td>0.3</td>
<td>300</td>
</tr>
<tr>
<td>Mary</td>
<td>0.6</td>
<td>300</td>
</tr>
<tr>
<td>Tom</td>
<td>1.2</td>
<td>300</td>
</tr>
<tr>
<td>Elisa</td>
<td>1.5</td>
<td>300</td>
</tr>
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</table>
Exposure assessment is not always as accurate as we think it is, hampers good correlations between intake and biomarkers.

- Average intake in the range of 0.3 – 1 μg/kg body weight per day, higher intakes occur
- Margin of Exposure (MoE) is far away from 10,000
- Reduction of exposure is possible, but MoE’s are still much smaller than 10,000
- Models to quantify risk-benefit are available?

Conclusion
Minimisation Options - Industry

Graz Workshop
13-14 June 2006
Hans Lingnert

Time Perspective

- April 2002
  Formation mechanism of acrylamide is not known

- June 2006
  More than 600 articles in the HeatoxNews database.
  137 on Formation and Chemistry
  133 on Ways to reduce

The Maillard Reaction?

- Toxic compounds
- Colour
- flavour
- Nutritional quality
- Microbial protection
- Anti-oxidants
- MAILLARD REACTION

Acrylamide Minimisation

- A balancing act!

- Total product quality
  The consumer is the judge

- Risk/benefit considerations
  Should be scientifically based

Minimisation strategies

- Reduce the content of reactants
  Asparagine, Sugars

- Influence the reaction
  Reaction pathways, Extent of reaction

- Promote degradation of acrylamide formed
Reduce the content of reactants

- Selection and control of raw materials
- Pre-treatment (washing, blanching, sifting, ...)
- Fermentation
- Enzyme treatment

Influence the reaction

- Processing conditions
  - Temperature
  - Time
  - Moisture
  - pH
- Recipe; Ingredients
  - Amino acids
  - Acids
  - Baking agents

Promote degradation of acrylamide formed

- Acrylamide content may be reduced at prolonged heating
  - Coffee roasting
- Food components reacting with acrylamide?

HEATOX contributions

- Reaction kinetics
  - Modelling of acrylamide formation as a function of processing parameters
  - Kinetics behind the formation and loss of acrylamide in low moisture systems
- Potato products
  - The influence of potato variety/cold storage on acrylamide production in potato crisps
  - A fry simulator for frying of French fries developed
  - Studies on low pH treatment and vacuum frying for potato crisps

HEATOX contributions

- Bread
  - Prolonged yeast fermentation reduce the acrylamide formation
  - Modified (steam) or new (IR, impingement) baking processes may reduce the acrylamide levels in bread
- Coffee
  - Relationships asparagine, sugars (various coffee varieties) roasting time and temperature evaluated

The CIAA Acrylamide Toolbox
Guidelines for minimisation

- Should take the continuous development of new knowledge into account
- Should recognize that each product and process needs its own solution
- Should offer a systems approach rather than fixed solutions

- The Toolbox
- The HACCP concept?
Home-cooking and acrylamide

Kerstin Skog
Department of Food Technology, Engineering and Nutrition

Attempts to reduce acrylamide may have impact on

- Product quality
  - Nutritional value
  - Microbiological safety
  - Sensory properties - flavour, taste, texture
- Formation beneficial compounds
- Risk – benefit approach

Crisp breads

- Fermented crisp breads contain less acrylamide than non-fermented
- Consumption of crisp breads is still considered as health promoting

Bread

- Prolonged fermentation of the dough reduces AA content in the final bread
  - reduced free asparagine content
- Applying glycine on the surface of the dough decreased acrylamide content in the bread and enhanced browning

Rice

- Low dietary intake of fried rice
- Acrylamide is found in fried rice, but at lower concentrations than in fried potatoes
  - Rice has less asparagine and less sugar
- Cereals have most of the asparagine in the bran layer, thus probably less acrylamide is present in fried white rice (but less dietary fibre)

Vegetables

- Acrylamide is formed in most types of foods during frying, baking and roasting
  - the amounts depend on how much asparagine and sugar are present
- Acrylamide levels are generally low in heated vegetables
- Consumption of fried vegetables has probably no significance for the total intake of acrylamide
Factors that can influence AA formation in “fried” potatoes

- Varieties - Storage conditions
  - Reconditioning at room temperature
- Pre-treatment
  - Blanching - soaking
  - Boiling before roasting and pan-frying
  - Adding citric acid, vinegar, rosemary
- Cooking
  - Type of equipment
  - Type/reuse of cooking oil
  - Size and shape of potatoes
  - Temperature and Time (Colour, Crispness)
- Reheating

Storage

- Cultivars vary, weather conditions have large impact even for the same cultivar
- Sugar and asparagine levels differ between varieties
- Cold storage induces sugar formation
- The influence of storage is different between varieties
  - Some varieties are adapted to cold storage
- Storage at 8-10 degrees Celsius – less sugar
  - However, this shortens the shelf life of potatoes
- Reconditioning = Keeping cold-stored potatoes at room temperature before use
  - reduces the sugar and thus the formation of acrylamide

What happens during deep-frying?

**Crust formation**

- Oil: 175ºC
- Inner Crust: 100ºC
- Water/vapour

Potato contain 80% water (no fat)
French fries 50% water (>10%fat)

Acrylamide is formed in the latter part of the cooking

Pre-treatment to reduce AA

- Blanching or soaking removes asparagine and sugar from the surface and results in lower acrylamide levels
- Parboiling reduces acrylamide formation
  - up to 40% less in roasted potatoes
- Citric acid, vinegar, rosemary
  - acceptable product?

Acrylamide – Cooking method

- Not in boiled or micro-waved potatoes
- in deep-fried, roasted, pan-fried potatoes
- higher levels when cooked from frozen (sometimes)
- acrylamide formation depends on the heat transfer, if it is hard or soft fried,
  not directly on the frying method as such
- the quality of the oil is of little significance
- thin or small pieces have larger surface area/volume than thick or big pieces and generally contain more acrylamide

Two-stage cooking

- Varying the temperature during cooking - a way to reduce acrylamide?
- Higher heat in the beginning to get a nice crust and colour and lower heat in the end, when most of the acrylamide is formed
  - Accuracy of domestic temperature controls?
Acrylamide and colour

- Colour codes to minimise acrylamide content?
- Strong relationship between colour in bread crust and acrylamide content
- Within one potato variety - the darker the crust, the more acrylamide
- Large differences between potato varieties in cooking time to obtain similar colour
- Not all samples ‘cooked’ at lighter colour
- Preferences for color and final moisture
  - a consumer acceptable product

Thank you for your attention
BEUC is a partner in the Heatox project, working in particular on Deliverables 59 and 60, which cover the communication of the research results to consumers and industry. We strongly believe in the importance of making the results of any research project widely available to the scientific community and most importantly relevant and understandable for consumers and citizens.

Heatox is a particularly important project and a lot of expectations have been created around its contributions to scientific knowledge, since the Commission has clearly stated that any decisions on how to manage the acrylamide risk would be made after the end of the Heatox project.

A lot more about acrylamide is how know thanks to the researchers who, across a number of EU countries, are working together to assess the risk and to develop minimisation strategies. This afternoon we will hear two presentations: one on perception of risk and one on how consumers deal with uncertainties. We will then split into five working groups covering three topics and, mindful of all the information that has been presented to us so clearly by the different speakers, in the course of the afternoon we will discuss how Heatox researchers and partners can work, in the last six months of the project, on some of the most pressing consumer and industry concerns. We will also be asked to suggest ways of delivering the results of the research in a format that is constructive and easy to use by regulators, industry and consumers.

Some of the ideas for the workshop and questions for the working groups were developed at the end of November 2005 by 30 or more consumer representatives from all over Europe. During a workshop which focussed on acrylamide it became very clear that:

- There is a need for clearer information on how to reduce the levels of acrylamide during home-cooking. Clearer messages on storage, cooking and diet need to be developed and conveyed to consumers through a number of different and trustworthy channels.

- The main hurdle is the communication of uncertainties and the notion of balance between risks and benefits. These are difficult concepts that need to be communicated to consumers in a honest way and not used to dilute good safety messages and, ultimately responsibilities.

- It is necessary to know how the different minimisation strategies in place are (or are no) working in order to develop the most appropriate regulatory approaches. There is a need for transparent monitoring programmes by both national authorities and industry.
Risk perception and food safety: where do European consumers stand today?

Carola Sondermann
EFSA Senior Press Officer

Objectives
- Assess how consumers in the EU perceive health-related risks and in particular food safety.
- Identify key concerns with respect to food safety
- Assess consumers’ views regarding action of public authorities
- Assess consumers’ trust in key information sources
- Eurobarometer jointly commissioned by EFSA and DG SANCO

Methodology
- Fieldwork: September 2nd – October 6th 2005
- Countries covered: 25 Member States
- Target group: In each Member State, national and other EU citizens aged 15+
- Methodology: Face-to-face interviews conducted in peoples’ homes
- Number of interviews: 24,643 interviews conducted by TNS Opinion & Social network

Main findings: Food Safety
- Consumer perception of food is positive; food safety not top-of-mind
- Food primarily associated with taste, pleasure and hunger
- Major food crises of past (eg BSE, dioxins) not cited by consumers as being top concerns today
- High level of awareness re EU food safety regulations (> 60%)
- Opinions divided re progress made in food safety (country differences)
- Overall, public authorities’ actions judged appropriate, in particular:
  - Decisions re food risks are science-based (nearly 6 out of 10)
  - Information re food risks (1 out of 2)
- Need for impactful risk communications:
  - Over 40% who hear of food risks in media either ignore story or worry and do nothing

Risk perceptions
- Risks in general
- Association with food
- Attitudes to food purchasing
- Food-related risks
- National concerns about food
### Risk perceptions

**Risks in general**

Question: I will read out a list of potential risks. For each of them please tell me how likely you think they are to happen to you personally.

<table>
<thead>
<tr>
<th>Risk Description</th>
<th>Likely</th>
<th>Not Likely</th>
<th>DK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental pollution damaging your health</td>
<td>81%</td>
<td>19%</td>
<td></td>
</tr>
<tr>
<td>Being injured in a car accident</td>
<td>84%</td>
<td>16%</td>
<td></td>
</tr>
<tr>
<td>A serious illness</td>
<td>43%</td>
<td>57%</td>
<td></td>
</tr>
<tr>
<td>Food you eat damaging your health</td>
<td>49%</td>
<td>51%</td>
<td></td>
</tr>
<tr>
<td>Consumer goods damaging your health</td>
<td>60%</td>
<td>40%</td>
<td></td>
</tr>
<tr>
<td>Being the victim of a crime</td>
<td>31%</td>
<td>69%</td>
<td></td>
</tr>
<tr>
<td>Being the victim of terrorism</td>
<td>20%</td>
<td>80%</td>
<td></td>
</tr>
</tbody>
</table>

**Environmental pollution damaging your health**

Likely: 36%
Not likely: 42%
DK: 22%

**Being injured in a car accident**

Likely: 47%
Not likely: 53%
DK: 10%

**A serious illness**

Likely: 49%
Not likely: 51%
DK: 0%

**Food you eat damaging your health**

Likely: 55%
Not likely: 45%
DK: 10%

**Consumer goods damaging your health**

Likely: 62%
Not likely: 38%
DK: 0%

**Being the victim of a crime**

Likely: 31%
Not likely: 69%
DK: 0%

**Being the victim of terrorism**

Likely: 20%
Not likely: 80%
DK: 0%

### Association with food - spontaneous

**Question:** When thinking about food, what words first come to mind? (MULTIPLE ANSWERS POSSIBLE)

- Taste: 21%
- Pleasure: 24%
- Health: 16%
- Necessity: 15%
- Conviviality: 10%
- Balanced diet: 5%
- Calories: 4%
- Greed: 2%
- Obesity: 2%
- Chemicals: 2%
- Local/national culture: 1%
- Guilt: 1%
- Diseases: 1%

### Attitudes to Food Purchasing

**Question:** When you go shopping for food, what would you say are the most important factors that influence your choice?

- Quality: 42%
- Price: 23%
- Appearance/freshness: 19%
- Taste: 17%
- You and your family's health: 16%
- Family preferences: 14%
- Habit: 11%
- Food safety: 9%
- Production methods: 7%
- Country of origin: 6%
- Brand name: 5%
- Convenience/availability: 4%
- Avoiding food allergies: 3%
- None (SPONTANEOUS): 3%

### Food-related risks - spontaneous

**Question:** What are all the things that come to mind when thinking about possible problems or risks associated with food?

- Food poisoning: 14%
- Chemicals: 13%
- Obesity: 12%
- Illnesses: 5%
- Gloves: 5%
- Food additives: 7%
- No problems or risk: 7%
Risk perceptions

Food-related risks

**Question:** For each of the following issues, please tell me if you are very worried, fairly worried, not very worried or not at all worried by it? AVERAGE WORRY INDEX

- Genetically modified products in food or drinks: 25%
- Additives like colours, preservatives or flavourings used in food or drinks: 22%
- Chemical substances that are formed during heating, baking, barbecuing or frying foods: 15%

Risk perceptions

- Awareness of EU regulations
- Citizens’ health as a priority
- Food-related actions - laws
- Level of action
- Evolution in food safety

Citizens’ health as a priority

**Question:** For each of the following statements, would you say that you totally agree, tend to agree, tend to disagree, totally disagree?

- Public authorities in the EU are quick to act when a danger to citizens’ health is identified: 55%
- Public authorities in the EU take citizens’ concerns about health risks very seriously: 54%
- Public authorities in the EU view the health of consumers as being more important than the profits of producers: 39%

Public authorities’ action

**Question:** For each of the following statements, would you say that you totally agree, tend to agree, tend to disagree, totally disagree?

- Public authorities take into account recent scientific evidence when they take decisions related to food risks: 58%
- Public authorities in the European Union do a good job in informing people about risks related to food: 49%
**Evolution in Food Safety**

**Question:** Compared to ten years ago, would you say that, overall, food safety has improved, stayed about the same or has gotten worse?

- **Has improved:** 28%
- **Stayed about the same:** 38%
- **Has worsened:** 9%
- **DK:** 29%

**Level of action**

**Question:** Would you say that usually public authorities’ actions in the European Union with regards to food safety risks...

- **Go beyond what is needed:** 8%
- **Are appropriate:** 12%
- **Are insufficient:** 47%
- **DK:** 33%

**Media exposure to health risks**

**Question:** Please tell me how recently you have heard or seen something in the media about the following health risks.

- **Smoking tobacco:** 37%
- **Obesity:** 21%
- **Alcohol:** 24%
- **Infectious diseases such as SARS:** 13%
- **Unsafe/unhealthy food:** 22%
- **Harmful chemicals:** 9%

- **This week:** 23%
- **Within the past month:** 19%
- **Within the past 6 months:** 7%
- **More than 6 months ago:** 9%
- **Never:** 37%

**Reaction to story**

**Question:** Please tell me how you reacted to the last story you heard about a type of food being unsafe or bad for your health.

- **You have permanently changed your eating habits:** 3%
- **You avoided the food mentioned in the story only for a while:** 16%
- **You got worried about the problem but finally you did nothing about it:** 23%
- **You have ignored the story:** 37%
- **Other:** 2%

**Most trusted communicators on food-related issues**

- **Consumer groups**
- **General practitioners**
- **Scientists**
**Sources of Information**

**Preferred sources**

*Question:* Suppose a serious food risk were found in fish or chicken. Who would you trust the most to inform you about this risk?

<table>
<thead>
<tr>
<th>Source</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Consumer groups</td>
<td>32%</td>
</tr>
<tr>
<td>Your physician/doctor</td>
<td>32%</td>
</tr>
<tr>
<td>Scientists</td>
<td>30%</td>
</tr>
<tr>
<td>Public authorities</td>
<td>22%</td>
</tr>
<tr>
<td>Media</td>
<td>17%</td>
</tr>
<tr>
<td>Food manufacturers</td>
<td>6%</td>
</tr>
<tr>
<td>Farmers</td>
<td>6%</td>
</tr>
<tr>
<td>Supermarkets/shops</td>
<td>3%</td>
</tr>
<tr>
<td>Other (SPONTANEOUS)</td>
<td>1%</td>
</tr>
<tr>
<td>None (SPONTANEOUS)</td>
<td>5%</td>
</tr>
<tr>
<td>DK</td>
<td>2%</td>
</tr>
</tbody>
</table>

**Conclusion**

- Europeans are worried about health-related risks
- Food has positive connotations of taste and pleasure and concerns regarding health and food safety are not top-of-mind
- Consumers identify a wide range of concerns and tend to worry most about factors which are beyond their control
- Clearly identifiable groups are more liable to worry about risks
- In order to be effective, communication on risks may need to be tailored to meet specific needs of target audiences
- Public authorities should seek to engage and involve consumers’ most trusted information sources

*Thank you!*
**Risk perception and communication: General issues**

Dr. Gene Rowe  
Risk and Consumer Science  
Institute of Food Research

**Presentation structure**
- Public perception of risk  
  - Why public perceptions are important  
  - How people perceive risks  
  - Are people wrong or just misunderstood?  
- Communication issues  
  - Rationale for communication  
  - Issue of public participation  
  - Perception of food risk management  
  - What is good and what is bad  
- Implications for the Acrylamide case?

**Public perception of risk**
- A variety of controversies in Europe over the last few decades have shown the power of public opinion (and consequent behaviour)  
- For example:  
  - BSE, Salmonella in eggs, combined MMR vaccine  
- These cases have been marked by official estimates that risks associated with hazards are low (at least initially!), but considerable public anxiety  
- Results of public concerns have been significant (e.g. economically), such as reduced consumption of beef and eggs, and reduced take-up of vaccine

**Contemporary Example: Growing GM crops commercially in the UK**
- Recent scientific review in UK (2003) has concluded risks are minimal  
- HOWEVER there is evidence of great public concern (public perceives risks as greater), demonstrated by:  
  - Direct action against GM crops by environmental activists  
  - Refusal of certain retailers to sell ‘GM foods’  
  - Media campaigns against ‘Franken-foods’  
  - Also, international tensions e.g. refusal of several African countries to accept aid shipments; tensions between USA and Europe  
- Results from Government-sponsored debate and various opinion polls confirm public concern
The Outcome

• Government has limited powers as any ban would have international consequences, because of the lack of scientific or legal justification
• Instead, Government based policy on result of FSE of 3 crops (2003), and gave permission to grow one of these - the Chardon LL maize
• BUT, it published two sets of guidelines on new regulations relating to genetically modified organisms, covering tighter labelling of GM products and monitoring for environmental effects…
• Bayer, the German biotech company, withdrew its application to grow a variety of GM maize, saying the crop was not economically viable, given constraints imposed upon it by the government.
• None of the major biotechnology companies applied to the European Union to grow GM crops in the UK in 2005 - well below the peak for 2001, which saw 159 applications [New Scientist, 24 April, 2004].
• Public ultimately have the power!

How do people perceive risks?

• Quantitatively, research has suggested that ‘laypersons’ tend to perceive risks as greater than ‘experts’, for a variety of potential hazards, e.g. chemical, ecological/environmental, nuclear waste
• However, closer look at data suggests that demographic and socio-economic differences explain the expert-lay differences (uncontrolled factors)
• That is:
  - Males perceive risks as less than females
  - Better educated perceive risks as less than less well educated
  - Also evidence that wealth (income), age, and ethnicity are correlated with degree of perceived risk

How do people perceive risks? (2)

• Qualitatively, research has suggested that ‘laypersons’ tend to perceive risks in a multi-dimensional manner, unlike the expert assessment of risk related simply to likelihood of human harm/death
• Psychometric research reveals generally 2 ‘dimensions’ of risk: one related to ‘dread’ (event is dreaded, likely to cause harm, likely to harm future generations), the other to ‘novelty’ or ‘familiarity’ (known to scientists/the public) (see example)
• However, some contention about interpretations, e.g. Sjoberg suggests there is a ‘tampering with nature’ dimension
• Results may also vary according to nature of hazard…

Assessing Perception of Food Hazards

How do people perceive risks? (3)

• Other research identifies other key factors that impact on risk perception, such as presence or absence of benefits and control over exposure
• For example, some evidence GM foods perceived negatively because they have no perceived benefits (so why buy/eat it?), and less willing to tolerate it because no perceived control over exposure (not labelled, and mixed with non-GM ingredients, etc.)
• Uncertain relationship between the various factors (e.g. probability of harm, benefits, control, uncertainty, naturalness)
• Absence of theory means difficult to predict outcomes, e.g. public response to acrylamide??

So... are the public wrong, or simply misunderstood?

• There ARE cognitive limitations that affect how we judge risks and uncertainties e.g.
  - over-estimation of small numbers (scaling problems)
  - optimistic bias (risks more likely to others than self)
  - availability bias (probability judged by easy availability of information…)
  - anchoring and adjustment (drawn to initial numbers and find difficult to adjust sufficiently)
  - base rate fallacy (ignoring base rates in the face of individuating information)
  - supra-additivity (probabilities of mutually exclusive/ exhaustive options summed to > 1.0)
ETC ETC…
BUT... people also have different values and concerns...  
- e.g. ‘foot and mouth’ crisis in UK: interpreted as public health problem by UK Government... but public perceived it as an animal welfare problem, hence concern at mass slaughter!  

So... sometimes wrong, but often also misunderstood!

Risk Communication Rationale
- If the public have different risk perceptions to the scientifically informed position, AND this difference is due IN PART to misinformation, this IMPLIES a need to communicate appropriate information to the public  
- The ‘deficit model’ assumes perceptions largely (entirely) due to lack of knowledge - the aim of RC thus to convince (unknowledgeable) public of ‘real’ risks according to expert assessment  
- More enlightened view acknowledges scientific uncertainty in the official position, and the relevance of values, and sees the role of RC as providing consumers with the information necessary to enable them to make informed decisions

Risk Communication Research
- Regardless of philosophy, the idea is we just need to find the right presentational manner in order to PERSUADE/INFORM the public  
- Research has attempted to find the magic presentational formula to do this e.g. using risk scales, comparing graphical vs numerical vs non-numerical information  
- However, RC not very successful. Why are the public not convinced about the safety of GM foods and crops? Why do people still smoke? Why do people still ‘drink and drive’? Why are people refusing MMR?

Risk Communication Problems
- Public reaction to risk communication is influenced by factors in addition to the content of the information itself, such as trust in the source providing the information  
- Unfortunately, communication sources (e.g. Government, industry) often untrusted:  
  - seen as having vested interests  
  - being wrong in the past (e.g. remember BSE!)  
- Importantly, UNCERTAINTY is recognised by public (scientists don’t have all the facts, so they MIGHT be wrong, and anyway, this implies that risk pronouncements have degree of value judgments, and are those of the experts, politicians, etc.)

Public Engagement Paradigm
- ‘Public engagement’ as new paradigm: a way to counter distrust, and to admit public values i.e. don’t just communicate at public, but also collect views and hold debates  
- Methods used include use of workshops, conferences, ‘citizens’ juries’...  
- Increasing drift to this paradigm, e.g. UK GM ‘public debate’  
- In spite of assumptions that engagement will improve trust, decrease dispute, lead to better decisions (etc.)
Perceptions of food risk management

- Recent research looking at perceptions of FRM part of an EU-funded project (SAFEFOODS)
- Focus groups, interviews, and surveys (5 different European countries)
- Consumers’ evaluations of FRM quality related to number of factors, including:
  - Presence of established systems of control
  - Proactive (as opposed to reactive) management
  - Trust in honesty of managers
  - Trust in expertise of managers
  - Quality/presence of adequate information
  - Degree of personal responsibility (voluntariness of hazard)

Conclusion

- Public perceive risks/uncertainties in a complex manner
- Risk Management needs to take this into account, because the public (consumers) hold much power
- ‘Effective’ risk communication is not simply a case of presenting ‘facts’ to public and convincing them
- Before communication, it’s important to understand what people know and what they want to know
- Communication should be targeted accordingly, and come from trusted sources
- The ‘public engagement’ paradigm is one possible solution (response to public lack of knowledge and lack of trust?), but its ‘effectiveness’ is uncertain
- There are many research questions still to answer!

Implications for the Acrylamide case?

- Risk perception:
  - Dread risk?: No (lo)
  - Unknown?: ? (??)
  - Involuntary?: No (lo)
  - Future generations?: No (lo)
  - Unnatural?: No (lo)
  - Benefits?: Yes (lo)

Prediction: not a hazard people will be particularly concerned about (as matters currently stand)…

But what do you think…?
## HEATOX Workshop 13 – 14 June 2006

### Working groups:

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Chair:</th>
<th>Rapporteur:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home-cooking</td>
<td>Lauren Jackson</td>
<td>Anika De Mul</td>
</tr>
<tr>
<td>Bitterhof</td>
<td>Almut</td>
<td>(H-ExP) European Commission, Health and Consumer Protection Directorate Belgium</td>
</tr>
<tr>
<td>Bianchi</td>
<td>Emanuela</td>
<td>Altoconsumo</td>
</tr>
<tr>
<td>Sammouris</td>
<td>George</td>
<td>KEPKA-Consumers’ Protection Center</td>
</tr>
<tr>
<td>Horváth</td>
<td>Gizella</td>
<td>OFE</td>
</tr>
<tr>
<td>Frandsen</td>
<td>Henrik</td>
<td>(H) Danish Institute for Food and vet. Research</td>
</tr>
<tr>
<td>Dalla Rosa</td>
<td>Marco</td>
<td>(H) Dept. of food science, University of Bologna</td>
</tr>
<tr>
<td>Skog</td>
<td>Kerstin</td>
<td>(H) Lund University, Division of Applied Nutrition and Food Chemistry Sweden</td>
</tr>
<tr>
<td>Rowe</td>
<td>Gene</td>
<td>Institute of Food Research</td>
</tr>
<tr>
<td>Busk</td>
<td>Leif</td>
<td>(H) National Food Administration</td>
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<tr>
<th>Group 2</th>
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<tbody>
<tr>
<td>Home-cooking</td>
<td>Beate Kettlitz</td>
<td>Jonas Mojica-Lazaro and Pelle T. Olesen</td>
</tr>
<tr>
<td>Göbel</td>
<td>Angela</td>
<td>Federal Office of Consumer Protection and Food Safety Germany</td>
</tr>
<tr>
<td>Matthews</td>
<td>Wendy</td>
<td>(H-ExP) Food Standards Agency UK United Kingdom</td>
</tr>
<tr>
<td>Hubená</td>
<td>Jarmila</td>
<td>Consumers Defence Association of the Czech Republic Czech Republic</td>
</tr>
<tr>
<td>Läänesaar</td>
<td>Linda</td>
<td>Estonian Consumers Union</td>
</tr>
<tr>
<td>Veale</td>
<td>Ruth</td>
<td>BEUC - The European Consumers’ Organisation</td>
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<tr>
<td>Hellenäs</td>
<td>Karl-Erik</td>
<td>(H) National Food Administration</td>
</tr>
<tr>
<td>Törnqvist</td>
<td>Margareta</td>
<td>(H) Stockholm University</td>
</tr>
<tr>
<td>Albert</td>
<td>Torbjorn</td>
<td>(H) National Food Administration</td>
</tr>
<tr>
<td>Grob</td>
<td>Koni</td>
<td>Official Food Control Authority of the Canton of Zurich Switzerland</td>
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<tr>
<th>Group 3</th>
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<tr>
<td>Cultural differences</td>
<td>Sigrid Lauryssen</td>
<td>Thomas Bjellås</td>
</tr>
<tr>
<td>Slorach</td>
<td>Stuart</td>
<td>National Food Administration Sweden</td>
</tr>
<tr>
<td>Spök</td>
<td>Armin</td>
<td>IFZ-Inter-University Research Centre for Technology, Work and Culture Austria</td>
</tr>
<tr>
<td>Trütscher</td>
<td>Angelica</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>Glatt</td>
<td>Hansruedi</td>
<td>(H) German Institute of Human Nutrition</td>
</tr>
<tr>
<td>Sønderman</td>
<td>Carola</td>
<td>EFSA - European Food Safety Authority</td>
</tr>
<tr>
<td>Lalle</td>
<td>Sam</td>
<td>(H-ExP) Safety and Environmental Assurance Centre, Unilever (ILSI) United Kingdom</td>
</tr>
<tr>
<td>Abrahamsson Zetterberg</td>
<td>Lilianne</td>
<td>(H) National Food Administration Sweden</td>
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<tr>
<td>Industry strategies</td>
<td>Geoff Thompson</td>
<td>Jeroen Knol</td>
</tr>
<tr>
<td>Thornley</td>
<td>Dell</td>
<td>EMRA - European Modern Restaurant Association</td>
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<tr>
<td>Petracco</td>
<td>Marino</td>
<td>Illycaffè</td>
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<td>Hamlet</td>
<td>Colin G</td>
<td>RHM Group Ltd</td>
</tr>
<tr>
<td>Dehne</td>
<td>Lutz</td>
<td>(H-ExP) BFR - Bundesinstitut für Risikobewertung</td>
</tr>
<tr>
<td>Gallani</td>
<td>Barbara</td>
<td>(H) BEUC - The European Consumers’ Organisation</td>
</tr>
<tr>
<td>Konings</td>
<td>Erik J.M.</td>
<td>Food and Consumer Product Safety Authority (VWA) The Netherlands</td>
</tr>
<tr>
<td>Klaveren</td>
<td>Jacob van</td>
<td>(H) RIKILT Institute of Food Safety</td>
</tr>
<tr>
<td>Sjöholm</td>
<td>Ingegerd</td>
<td>(H) Lund University, Division of Food Engineering Sweden</td>
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<th>Rapporteurs:</th>
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<tbody>
<tr>
<td>Industry strategies</td>
<td>Eleni Alevritou</td>
<td>Arwa Mustafa and Erik Petterson</td>
</tr>
<tr>
<td>Stadler</td>
<td>Richard</td>
<td>Nestlé Product Technology Centre</td>
</tr>
<tr>
<td>Haraldsson</td>
<td>Roland</td>
<td>PPM AB</td>
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<tr>
<td>Lineback</td>
<td>David</td>
<td>(H-ExP) JIFSAN, Univ. of Maryland</td>
</tr>
<tr>
<td>Wenzl</td>
<td>Thomas</td>
<td>(H-ExP) Institute for Reference Materials and Measurements Belgium</td>
</tr>
<tr>
<td>Becalski</td>
<td>Adam</td>
<td>Health Canada, Food Research Division</td>
</tr>
<tr>
<td>Lingnert</td>
<td>Hans</td>
<td>(H) SIK – The Swedish Institute for Food and Biotechnology Sweden</td>
</tr>
<tr>
<td>Alexander</td>
<td>Jan</td>
<td>(H) Norwegian Institute of Public Health</td>
</tr>
<tr>
<td>Murkovic</td>
<td>Michael</td>
<td>(H) Technical University of Graz</td>
</tr>
</tbody>
</table>
Home-cooking Guidelines

Questions to discuss
- Is there anything to add to the state of the art as described below and as presented during the introductory parts of the workshop?
- Is the scientific basis adequate for issuing guidelines to consumers on healthy home-cooking and consumption of cooked foods?
- Could HEATOX fill any gaps the last six months?
- Is the material available useful as advice to consumers?
- How should HEATOX structure the end deliverable Guidelines to consumers on healthy home-cooking and consumption of cooked (D59) in order to make it as useful as possible?
- What is the role of consumer organisations and industry in the dissemination of the HEATOX results?
Acrylamide in heated food – short general literature overview

Contents:
Toxicology
Occurrence in food
Intake
Ways to reduce occurrence
Consumers: Ways to reduce acrylamide in home cooking
Consumers: Ways to reduce acrylamide in consumption
Risk management options
Links to advice on acrylamide
General links on acrylamide

Toxicology

Hazard
Acrylamide is nerve toxic at high doses.

Furthermore, large studies in rat and mouse have shown that acrylamide increases the tumour frequency in different organs. Studies on cells show that it is damaging DNA, which indicates that there is no threshold effect, i.e. there is no dose of acrylamide so low that it does not increase the risk of cancer.
The WHO International Agency for Research on Cancer, IARC, classifies acrylamide as probably carcinogenic to humans (Class 2A). Other substances classified as probably carcinogenic to humans are Ultraviolet radiation A, B and C and the pesticide Chloramphenicol.

Risk
The risk for a human to get cancer is roughly 1 out of 3 during lifetime. The risk to get cancer by eating 50 microgram acrylamide/day is estimated to be 1-10 in 1,000.
Acrylamide is common in many different foodstuffs e.g. pommes frites, coffee, bread, etc, and a cancerogen effect is not likely to be detected in any epidemiological study. Taken as a whole the cancer risk caused by acrylamide in food is probably higher than many other substances in food, e.g. benz(a)pyrene, aflatoxin and benzene.
To regulate a cancer-inducing substance without thresholds effects, authorities usually have applied a maximum level that gives an estimated risk of 1 cancer in 100,000 - or 1 in 1,000,000 - during lifetime exposure.

Risk evaluation
EFSA (The European food Safety Authority) suggests Margin of Exposure as a helping instrument for risk manager. Substances with a Margin of Exposure of 10,000 or higher, can be considered as of low concern from a public health point of view, and might be reasonably considered as a low priority for risk management actions.

The expert group evaluation of JECFA (Joint FAO/WHO Expert Committee on Food Additives) concluded in February 2005 that with an average intake of 1 microgram acrylamide/kg bodyweight and day the Margin of Exposure is 300. The group considered this margin to be low for a substance that is DNA-harming and carcinogenic.
At the same meeting the Margin of Exposure for PAH was estimated to 25,000.
Occurrence in food
- Acrylamide is a chemical that is found in large amounts in foods rich in starch cooked at high temperatures; i.e. fried, baked, deep fried. High in potato, some crisp bread and biscuit; Medium in breakfast cereals; Low in meat and white bread. It is also found in other food at lower amounts, e.g. tinned (canned) including food for children.
- Only traces are found in boiled food.
- Acrylamide is formed during the Maillard reaction, which is a browning reaction between sugar and amino acids that gives appealing odours and tastes to foods like bread and French fries. Acrylamide is formed mainly by the reaction between sugar and the amino acid asparagine, the asparagine that is free and not bound in proteins.

Intake
The major contributing foods to the mean total exposure for most countries were:
- Potato chips (US=French fries), 16-30 %
- potato crisps (US=chips), 6-46 %
- coffee, 13-30 %
- pastry and sweet biscuits (US=Cookies), 10-20 %
- bread and rolls/toasts, 10-30 %

Others foods items contributed less than 10 % of the total exposure according to JECFA evaluation.
Canned food and porridges make a significant intake for small children.
Bread and coffee have low acrylamide content, but the intake is big as these foods are eaten a lot.
(see “General links” below, FDA: Exploratory data)

Total daily intake
Some studies:
Belgium: The estimated dietary intake of acrylamide per person given as the
5th percentile: 0.19 microgram/kg bodyweight and day
50th percentile: 0.51 microgram/kg bodyweight and day
95th percentile: 1.09 microgram/kg bodyweight and day

Germany: 0.3 to 0.8 microgram/kg bodyweight and day. Higher for children.
Netherlands: The mean acrylamide exposure of the NFCS participants was 0.48 microgram/kg bodyweight and day.

Sweden: The estimated dietary intake of acrylamide per person (total population)
5th percentile: 9.1 microgram/day
50th percentile: 27 microgram/day
95th percentile: 62 microgram/day
(mean 31 microgram/day).

An average daily intake of 35 microgram corresponds to 0.5 microgram per kg body weight and day (bodyweight 70 kg).
Ways to reduce occurrence

Formation factors
Thermal input (cooking time and temperature)
Amount of precursors (presence of asparagine + sugars in raw foods)
Water content
pH (acidity)
Other substances interfering with formation or promoting degradation of acrylamide

Ways to reduce

Raw materials:
- Selection and development of varieties,
- optimised cultivation and storage conditions, etc.

Recipe and additives:
- Amino acids, (added glycine to dough competes with asparagine in reaction with sugar, but gives darker product and might influence taste)
- pH-lowering compounds, etc. (soaking in citric acid solutions reduces acrylamide, but might influence taste)

Pre-treatment and process conditions:
- Washing, soaking or blanching,
- Fermentation or enzyme treatment, (removing asparagine with asparginase)
- Pre/post-drying, (dryness prolongs shelf life. In potato crisps post-drying can reduce frying time, while still maintaining shelf-life)
- thermal input and profile, etc. (Lower temperature and longer time might reduce acrylamide formation)
Consumers: Ways to reduce acrylamide in home cooking
Listed examples of advice from different countries. Links to advice on page below.

**Potato products** (these examples are taken from web pages listed below)

**Temperature and colour**
1. For homemade fries, pay careful attention to the oil temperature. Remember, acrylamide is related to high temperature cooking. Health Canada
2. Deep fry French fries to a golden colour at temperatures not exceeding 170-175°C. Do not cook any longer than necessary, and avoid dark-coloured French fries. Health Canada
4. Möglichst mit Margarine braten, um eine Überhitzung zu vermeiden.
5. Bratkartoffeln besser aus gekochten Kartoffeln zubereiten. Rohe Kartoffeln etwa eine Stunde wässern.
6. Die Temperatur beim Backen mit Umluft sollte 180 Grad Celsius, beim Backen ohne Umluft 200 Grad Celsius nicht überschreiten.
7. Backpapier verwenden
8. Pommes, Blechkartoffeln, Plätzchen und Pizza nicht zu stark bräunen.
   In der Fritteuse sollten 175 Grad Celsius nicht überschritten werden. Pommes in kleinen Portionen so lange frittieren, bis die Pommes goldbraun und nicht verbrannt sind. Dicke Pommes bevorzugen und gleichmäßig auf dem Backblech verteilen. was-wir-essen.de
10. Volg de aanwijzingen op de verpakking van aardappelproducten en frites en bak ze niet langer dan nodig is. Frituurvet is goed op temperatuur bij 175-180 Â°C.
11. Frites geschikt voor de oven bevatten meer suikers. Als deze worden gefrituurd, wordt het acrylamideaengehalte onnodig hoog. Bak deze fritessoorten daarom alleen in de oven en niet langer dan de aanwijzingen op de verpakking.
12. Gaar aardappelen voor het bakken niet in de magnetron. Voedingscentrum, Netherlands
13. Ved tilberedning av mat hjemme bør forbrukere unngå hardsteking av maten og forøvrig følge stekeanvisningen på pakningene nøye. Mattilsynet, Norway

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**Table: Acrylamide Levels in French Fries**

<table>
<thead>
<tr>
<th>Baking Time (min)</th>
<th>Acrylamide (ug/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1000</td>
</tr>
<tr>
<td>5</td>
<td>2000</td>
</tr>
<tr>
<td>10</td>
<td>3000</td>
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<tr>
<td>15</td>
<td>4000</td>
</tr>
<tr>
<td>20</td>
<td>5000</td>
</tr>
<tr>
<td>25</td>
<td>6000</td>
</tr>
</tbody>
</table>

Range for acceptable product quality
14 Bei zu starker Erhitzung von Lebensmitteln können eine Reihe von gesundheitlich bedenklichen Stoffen wie Acrylamid entstehen und wertvolle Inhaltsstoffe zerstört werden. Um dies zu vermeiden, sollten Lebensmittel nicht zu lange und nicht bei zu hoher Temperatur zubereitet werden: vergolden statt verkohlen.
15 Der Frittierprozess ist sorgfältig zu beobachten und muss rechtzeitig beendet werden. BAG, Schweiz

16
A. Öl bei ca. 170 °C halten. In heisserem Öl bilden sich schnell überfrittierte Stellen mit sehr hohen Acrylamidgehalten. Wichtig: Die Temperaturangabe der Fritteuse regelmäßig mit einem Thermometer prüfen!
B. Portionen von etwa 50–100 g Kartoffeln pro Liter Öl in der Fritteuse: Die Öltemperatur soll etwas sinken, aber ca. 145 °C nicht unterschreiten. Größere Mengen in Portionen frittieren, wobei das Öl zwischen jeder Portion wieder aufgeheizt werden muss.

Storage temperature
17 Do not store potatoes below 8ºC. Low temperature storage can increase the components that contribute to acrylamide formation. Health Canada
18 Bewaar aardappelen niet in de koelkast of in een koude kelder. Om te voorkomen dat aardappelen uitlopen, is het af te raden grote voorraden te bewaren. Voedingscentrum
19 Ungekochte Kartoffeln gehören nicht in den Kühlschrank! Kartoffeln sollen vor Licht geschützt und nicht unter 10ºC aufbewahrt werden. BAG, Schweiz

20 Lagerung: Kartoffeln dürfen nicht unter ca. 8 °C gelagert worden sein (Problem der Keimhemmung bei Langzeitlagerung). Ungekochte Kartoffeln nicht im Kühllraum oder Kühlschrank lagern. Auch geschälte und geschnittene Kartoffeln nicht länger als ca. 24 Stunden kalt lagern. Kantonalen Labors Zürich

Preparation
21 Wash or soak fresh cut potatoes in water for several minutes before frying. This can reduce the components that contribute to acrylamide formation. Health Canada

22 Schnitt: Keinen allzu feinen Schnitt wählen (mindestens 7 mm). Kleine und unregelmässige Kartoffelstücke aussortieren (diese bräunen zu schnell).
23 Wässern: Die geschnittenen Kartoffeln mit kaltem oder boilerheissem Wasser überdecken und mindestens ca. 15 min. stehen lassen.
24 Blanchieren: 2–3 Minuten bei 140 °C vorfrittieren verbessert die Knusprigkeit. Kantonalen Labors Zürich

25 Rösti preparation:
A. Gekochte Kartoffeln vor der Verarbeitung mindestens mehrere Stunden im Kühlschrank lagern, damit sie fester werden und die Rösti eine bessere Struktur erhält. Für die gekochten Kartoffeln ist kalte Lagerung kein Problem denn Kochen inaktiviert die Enzyme, welche Zucker frei setzen.
B. Die geraffelten Kartoffeln salzen und würzen, bevor sie in die Bratpfanne gegeben werden. Sie sollen in der Pfanne nicht mehr gemischt werden, weil sonst das für den Bratprozess wichtige Fett in den Kartoffelkuchen verloren geht.
C. Mit genügend Fett oder Öl (20-30 g/Portion) braten: Das Fett verteilt die Hitze und verhindert damit die Bildung schwarzer Stellen; die Bräunung wird gleichmässiger.
D. Mässige Erhitzung vermindert die Acrylamidbildung. Anfangs darf die Temperatur ziemlich hoch sein (Acrylamid entsteht erst nach der ersten Krustenbildung), z.B. Stufe 8 auf einer Skala von 10, sollte aber nach etwa 3 min auf 6 reduziert werden. Nach 10-12 min wird der Kartoffelkuchen gekehrt (notfalls mit Hilfe eines Tellers) und nochmals 8-10 min auf der anderen Seite gebraten.
E. Nach dem Kehren bewirkt die Zugabe von etwas Fett (ca. 10 g) vom Pfannenrand her eine schönere Randbildung.

F. Starke Bräunung verhindern!

G. Die Zubereitung aus gekochten Kartoffeln ergibt meistens weniger Acrylamid als jene aus rohen Knollen, aber die Unterschiede sind moderat. Kantonalen Labors Zürich

**Other**

26 Kartoffelsorte: Kartoffeln mit gelbem Fleisch, hohem Stärkeeinhalt, aber wenig Fructose und Glucose auswählen (z.B. Agria, Granola, Eba). Kantonalen Labors Zürich

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**Cereal products**

**Toasting bread**

27 Toast to the lightest colour acceptable. Health Canada
28 Toast nur leicht anrösten. was-wir-essen.de

**Baked goods**

29 The crust of toast or bread will have higher levels of acrylamide than the remainder, even though these levels are lower than those in french fries and potato chips. Where appropriate, you may wish to remove crusts. Health Canada
30 Brot, Pizza und Kuchen nicht zu stark bräunen. was-wir-essen.de

**Other food products**

**Coffee**

**Consumers: Ways to reduce acrylamide in consumption**

*Listed examples of advice from different countries. Links to advice on page below.*

31 Alternativen zu belasteten Lebensmitteln: Pfannkuchen, Bratlinge und Gratins, Kartoffeln dünsten oder kochen, zum Knabbern eignen sich ungeröstet Nüsse, Studentenfutter und Obststücke was-wir-essen.de
32 Wer sein persönliches Risiko reduzieren möchte, sollte seine Acrylamid-Aufnahme so weit wie möglich senken, d. h. Lebensmittel mit einem hohen Gehalt an Acrylamid, wie Kartoffelchips, Pommes, Kartoffelpuffer sowie Kaffee, löslicher Kaffee und Getreidekaffee nur noch in geringen Mengen aufnehmen. was-wir-essen.de
33 eet gevarieerd en niet te veel chips, zoutjes en patat. Voedingscentrum, Netherlands
34 Mattilsynet opprettholder rådet om å spise variert og balansert, samt redusere inntak av stekt og fritert mat. Mattilsynet anbefaler fortsatt storspisere av chips og pommes frites å redusere inntaket. Det samme gjelder stordrikkere av kaffe. Norway
35 Eine ausgewogene Ernährung mit reduziertem Fettanteil und reich an Früchten und Gemüse bietet zusammen mit sportlicher Betätigung die besten Voraussetzungen für eine gute Gesundheit. BAG Schweiz.
36 You do not need to change your diet or the way in which you cook your food – but you should continue to eat a healthy, balanced diet.// The Agency is not advising people to stop eating any particular foods. However, the Agency advises that as part of a balanced diet you should limit the amount of fried and fatty foods you eat, including chips and crisps. FSA, UK.
37 Until more is known, FDA continues to recommend that consumers eat a balanced diet, choosing a variety of foods that are low in trans fat and saturated fat, and rich in high-fiber grains, fruits, and vegetables. FDA, USA.
Risk management options

Some examples

- **Ban:**
  chloramphenicol, a cancerogenic pesticide like (IARC Group 2A)

- **Maximum limit:**
  aflatoxin, a cancerogenic toxin from mold,
  3-MPCD, a process contaminant occurring in soya sauce,
  dioxins, an industrial contaminant slow in degradation (persistent).

- **labelling**
  for example
  - **Warning labels** - smoking or alcohol.
  - **Threshold labelling** required above certain levels - caffeine in soft drinks.

- **Voluntary actions by industry**
  - for example: benzene in soft drinks. See FSA, UK:
  - minimizing acrylamide strategy in Germany

- **Consumption and cooking advices by national authorities**
  - Consumption advice to pregnant women on mercury in fish
  - Cooking advice on PAH: ”Don’t grill or toast too much”
  - Cooking instructions on home appliance or food package

**EU has already two maximum limit levels for acrylamide concerning food:**
1. Limit of migration into or on to food from materials in contact with food: Not Detected at Detection Limit: 10 micrograms/kg)
2. Drinking water: Maximum limit 0,1 microgram/litre.

California proposed a different approach to tackling carcinogenic substances in food under the so-called Proposition 65:
Warning labels on certain food containing acrylamide, and a maximum level of 200 microgram acrylamide/kg on bread and cereals.
(This proposal is withdrawn from 8 April. A new proposal will be published within 60 days. See link below.)

**National monitoring programmes to date**

**Germany:** Minimierungskonzept/minimisation strategy by the authorities and industry.
http://www.bvl.bund.de/cln_027/nn_493378/DE/01__Lebensmittel/03_UnerwStoffeUndOrganis men/04__Acrylamid/00__Minimierungskonzept/minimierungskonzept__node.html__nnn=true
(to translate that web page into English, you can use this web page: http://babelfish.altavista.com/babelfish/tr)

**Sweden:** Certain food groups will be monitored by the Food Administration 2006-2009, to see if acrylamide levels are decreasing.
**Links to advices on acrylamide**
(examples)

**Canada**, Health Canada: march 2005
english: Acrylamide - What you can do to reduce exposure
francais: Acrylamide - Comment réduire l'exposition

**Germany**, Was-wir-essen.de:
Acrylamid tipps
http://www.was-wir-essen.de/sonstiges/schadstoffe_a.php
Foren Acrylamid: Fragen och expertantworten
http://www.was-wir-essen.de/fusetalk/categories.cfm?catid=9

**Netherlands**, Voedingscentrum: Acrylamide, Algemene adviezen
http://www.voedingscentrum.nl/voedingscentrum/Public/Dynamisch/voedselveiligheid/%28milieu%29verontreiniging/acrylamide/algemene+adviezen.htm

**Norge**, Matportalen: Spørsmål og svar om akrylamid
http://matportalen.no/Matportalen/Saker/1052216588.16

**Switzerland**: deutsch: Bundesamt für Gesundheit: Empfehlungen für die Konsumentinnen und Konsumenten
francais: Office fédéral de la santé public: Recommandations destinées aux consommateurs
Kantonales Labor Zürich:
- Hintergründe und Tipps für eine gute und acrylamidarme Rösti
- Tipps zur Zubereitung von acrylamidarmen Pommes frites
- STOP.Acrylamid - Acrylamid in Pommes frites
http://www.klzh.ch/infomaterial/index.cfm

**United Kingdom**: FSA consuming advice
http://www.eatwell.gov.uk/healthissues/factsbehindissues/acrylamide/

**USA**, FDA: Acrylamide Questions and Answers
http://www.cfsan.fda.gov/~dms/acryfaq.html

**CIAA** Acrylamide Toolbox 23 Sep 2005 Rev 6
General links on acrylamide

IARC, UN International Agency for Research on Cancer:  
Monographs and Classification Groups,  
Group 2A - Probably Carcinogenic to humans

JECFA's (Joint FAO/WHO Expert Committee on Food Additives) website on acrylamide  

EFSA on Margin of Exposure: Proposed harmonisation of risk assessment methodology  

Swedish National Food Administration
Acrylamide in food  

The European Commission DG Sanco website on Acrylamide in food  
http://ec.europa.eu/comm/food/food/chemicalsafety/contaminants/acrylamide_en.htm

Acrylamide Information Base of Research Activities in the EU, compiled by the European Commission  

IRMM/JRC: Acrylamide monitoring database with Evaluated data (Excel 980kB) from 5200 products analysed June 2005.  

Acrylamide Infonet, The FAO/WHO Acrylamide in Food Network - operated by JIFSAN  
http://acrylamide-food.org/index.htm

CFSAN, FDA, USA  
http://www.cfsan.fda.gov/  
Exploratory data  
http://www.cfsan.fda.gov/~dms/acrydat2.html

California, OEHHA: Acrylamide and Proposition 65  
http://www.oehha.org/prop65/acrylamide.html
Some answers to the questions raised at the BEUC Working Group on Home-Cooking held in Brussels in November 2005

What do consumers need to know about acrylamide and how can they minimise its formation in the kitchen? The following points were raised/discussed:

1. Importance of time and temperature in home-cooking. Checking temperature is not practical in the kitchen - could colour indications be used instead? What is the best advice on the level of browning (when to remove from the heat)?

   Acrylamide is formed in the latter part of the cooking. Often, but not always, there is a good correlation between colour and acrylamide level. Advice based on colour can be produced for French fries and toasted bread, for example.

2. There is a need for clear advice on potatoes: storage, difference between using fresh or frozen potatoes, differences between qualities and varieties of potatoes.

   - To reduce potential acrylamide formation during cooking, potatoes should be stored above 8 degrees Celsius. This shortens the shelf life of potatoes.
   - Keeping cold-stored potatoes at room temperature at home for a week before use reduces the sugar to some extent and consequently the formation of acrylamide during cooking. This process is called reconditioning.
   - Sugar levels vary between varieties, as does the effect of storage on the sugar levels.
   - The influence of storage is quite different between varieties. There are usually a lot of varieties within a country, and almost every country has its own varieties.

3. In general, when cooking, is it better to cook from fresh or frozen? Bake or fry? Prepare thick or thin chips? Blanching?

   It is difficult to provide straight answers to these questions since there are a lot of variables involved.
   - Fresh or frozen has no significance.
   - Baked or fried has no direct significance, more so if it is hard or soft heat-treated.
   - Thin or small pieces give more acrylamide than thick or big pieces, since the surface area is larger in relation to volume.
   - Blanching or soaking removes asparagine and sugar from the surface and gives lower levels to a varying degree, but method and food product matter.
4. Is a two-stage cooking (low heat to cook with subsequent browning on higher heat) recommended?

- According to CIAAs Toolbox 5.2.2 it has little effect.
- Varying the temperature during cooking might be a way to reduce, but there is no general rule. With potato crisps industry has reduced acrylamide levels by applying high heat in the beginning and lower heat in the end, where most of the acrylamide is formed.

5. Bread dough: If yeast-leavened bread is let to stand for a longer period does this have an influence on the level of acrylamide?

Prolonged fermentation of the dough lessens the free asparagine content and thereby the acrylamide content in the final bread.

6. What are the levels of acrylamide in vegetables other than potatoes?

In principle acrylamide is formed in all foods that are fried or baked depending on how much asparagine and sugar are present. Few, if any, vegetables have so high levels and/or are consumed in such amount, that it has any significance for the total intake. Look at the list from FDA.

7. Does deep or shallow frying make any difference?

- You will probably not get the same product.
- Acrylamide formation depends on the heat transfer, if it is hard fried or soft fried, not directly on the frying method as such.

8. Does the quality of the oil make a difference?

It is of little significance.

9. Is there an issue with fried rice and frying boiled potatoes?

- Acrylamide is also formed when frying boiled potatoes.
- Fried rice not a big issue. Acrylamide is formed when rice is fried, but to a less extent than in potatoes. Rice has less asparagine and less sugar.

10. Is there a difference between brown or white rice?

Possibly. Usually cereals have most of the asparagine in the bran layer. More research is needed, but probably not justified due to low dietary intake.

11. What are the main issues with crispy breads?

- Fermented crisp breads have significantly less acrylamide the non-fermented.
- Consumption of crisp breads is still considered as health promoting.
Questions for discussion

1. What is the role of consumer organizations and industry in the dissemination of the HEATOX results? Clarification- Industry refers to primary producers and food manufacturers

Food Industry

A. Food industry may have a role educating the consumer---information on food label.

B. The label should give cooking instructions so that acrylamide levels are reduced.

C. Guidelines for French fry products- manufacturer of French fries may include instructions on label how to cook French fries in a manner as to decrease acrylamide formation. For example, cook (bake or fry) to a golden color rather than brown color.

D. Raw potato producers- package of potatoes may suggest which recipes or cooking methods for a particular potato variety or cultivar- e.g. potatoes with high reducing sugar levels should be cooked at lower temperatures (e.g. boiled potatoes).

E. Label should indicate level of color of cooked food (via a picture or with words) rather than temperatures/times since level of surface browning correlates highly with acrylamide levels in some products.

F. Picture on front of food package may be used to show food cooked in a manner as to decrease acrylamide levels- e.g. French fries pictured on the front of a package should show golden French fries rather than a brown fries.

G. A question was raised about whether the food industry is willing to put cooking instructions on the label.

H. Food industry may want to include cooking instructions on label if they are worded properly, i.e. produce a more healthy product rather than reduce the level of acrylamide (or carcinogen).

I. May be useful indicate on label a link to consumer organization website that gives advice on ways to reduce acrylamide formation during cooking. In this way, industry and consumers can work together on this message.

J. Cooking guidelines, as presented on the food package, should also be given on food service products (e.g. for restaurants/food service operations/catering operations).

Consumer organizations

A. Information from HEATOX project should be distilled down to guidelines (written by scientists). These guidelines should be disseminated by the consumer group(s).

B. Information from consumer groups should be disseminated to:
   a. consumers
   b. restaurants/catering
   c. supermarkets
   d. schools, including home economics programs in public schools and cooking schools
2. How should HEATOX structure the end deliverable “Guidelines to consumers on healthy home-cooking and consumption of cooked foods (D59) in order to make it as useful as possible?

A. Make sure the guidelines are concise and clearly written (1-2 pages, maximum) with pictures
B. Guidelines should be divided by commodity (e.g. potato products, bread products, etc.)
C. There should be more detailed information in a longer document if the consumer has a desire to find out more about acrylamide and how to reduce levels in the diet. This could consist of a link to a website that has the more in depth document.
D. There should be an introductory statement in the guidelines that consumers should eat a varied diet with an abundance of fruits and vegetables (basic dietary guidelines) followed by more detailed/specific information on how to reduce acrylamide intake.
E. There may be a need to develop guidelines that are country/culture specific.

3. Is the material available useful as advice to consumers?

A. Information as presented in the HEATOX Workshop folder is useful and sound, but needs to be summarized and condensed.
B. The information needs to be put into a more consistent format.
C. Pictures should be included, but there may be problems with consistency when printing using different printers, etc.
D. There is a need to show, via pictures or diagrams, which foods contain acrylamide how much each of these foods contribute to total daily intake of acrylamide.
E. At this point of time, scientists can not comment on what constitutes a safe level of intake of acrylamide.

4. Could HEATOX fill any gaps in the last six months?

A. A major knowledge gap is how consumers prepare their food and how much of acrylamide intake is due to home-prepared foods.
B. A survey is needed on home prepared foods:
   a. How do consumers prepare their foods at home?
   b. How often do you prepare each of the foods that contribute to acrylamide intake?
C. More information is also needed on the amount of variation in acrylamide levels in home-prepared foods.
D. It is not likely that these research gaps can be filled in the last months of the HEATOX project.

5. Is the scientific basis adequate for issuing guidelines to consumers on healthy home-cooking and consumption of cooked foods?

A. Information in HEATOX folder has all information known to-date about acrylamide formation in food and could be condensed and summarized as guidelines for consumers.
B. Some unclear information, e.g. about size and shape of French fries and how these factors affect acrylamide formation needs to be clarified.
C. Is there a need to reduce acrylamide levels in all food products?
D. Unclear if there be guidelines for consumption of acrylamide-containing foods since some high-fiber foods also contain acrylamide.
E. It may be premature to make special dietary recommendations to children concerning acrylamide.

6. Is there anything to add to the state of the art as described below and as presented during the introductory part of the workshop?
A. More information is needed about home food preparation
   a. Which foods (containing acrylamide) are prepared at home and how often.
   b. Cooking methods used to prepare foods at home (e.g. fried, baked, cooked to high degree of surface browning, etc.)
B. More information may be needed on acrylamide bioavailability---e.g. coffee vs. coffee w/ milk

Slides:
Consumer organization and industry role in dissemination HEATOX’ results
• Basic labelling info, with colour picture
• Framed positively
• Involvement of consumer with information on labels

• Information to:
  – Restaurants (preparation)
  – Supermarkets (storage/ preparation)

• HEATOX document → consumer organisation → consumer

How should HEATOX structure of end deliverable ‘guidelines to consumers on healthy home cooking and consumption of cooked foods’
• short 1 page with pictures
• With link to detailed document (5pages)
  – Country / culture specific
• Include:
  – Basic dietary guidelines
  – Product specific

Is the available material useful as advice to consumers?
• Condens, summarize, it looks sound information

Gaps
• Home cooking survey on cooking practice
Group 2 – Home-cooking

Practices that can influence AA formation
- Storage of potatoes (home)
- Preconditioning at room temperature (home)
- Boiling before roasting and panfrying (both)
- Blanching – soaking (industry)
- Adding citric acid, vinegar, rosemary (both)
- Reheating (home)
- Type of cooking oil (home)
- Reuse of cooking oil (home)
- Type of equipment (home)

What to look at?
- Storage conditions (potatoes)
- Cooking
  - Colour
  - Temperature
  - Time
  - Organoleptic properties; Crispness etc.

Recommendations of the working group on home-cooking guidelines
- Encourage authorities and academia to focus research out relative exposure from home cooking, eating out and processed food
- Identify all research activities in the home cooking area
- Co-operation with catering sector?
- Carry-over learning from the Toolbox

- Risk/benefit in the home cooking area to be considered
- Toolbox for authorities, consider national specificities, therefore as a deliverable:
  - National advice
  - Raw material: Potatoes, cereals

- Look at potatoes first, because they are more home-cooked, (sugar variety)
- Cereals also (asparagine)
Working group on Cultural differences

Eating habits and patterns vary throughout Europe. So does the way to prepare food. This will influence the dietary intake impact of heat-generated food toxicants in the diet.

- What knowledge has been gathered on a European level which could be relevant to issue?
- How do cultural differences influence the communication processes related to heat-generated food toxicants?
- Should HEATOX take cultural differences into account when structuring the guidelines and strategies and if yes, how could this be done?
- How should HEATOX structure the end deliverables in question (Guidelines to consumers on healthy home cooking and consumption of cooked foods (D59) or Manual on strategies to industry and restaurants etc. to minimise acrylamide formation (D60) in order to make them as useful as possible?
Group 3: General conclusions - cultural differences

What knowledge has been gathered on a European level which could be relevant to the issue?
The exposure levels in countries are very similar, and not all food types has been included into the exposure assessments (ex. coffee). Also, some particular national food stuffs has not been included

More insight into consumer habits and to the exposure levels concerning the different particular national food items are needed in order to conclude something on the cultural difference.

Each country must add levels of more particular food stuffs

How do cultural differences influence the communication processes related to heat generated toxicants
There exists different communication processes. It is important to know whom the consumer trust. These communication channels could be: Authorities, newspaper, flyers, consumer organization etc to name a few channels. They all have variable trust from the consumers dependent on the country. There might be large cultural differences in the context of communication. What would be the effective means of communication?

Information should be tailored according to different authorities

Should HEATOX take cultural differences into account in the in guidelines and strategies. If yes, what and how.
What the most important foodstuffs to focus on is cultural dependent. (Coffe in Norway, bisquits in germany, fries in England etc). It could be important to identify what food items which contributes the most to the dietary exposure in the respective country. There is a need of more data on particular food items (see question 1)

How to structure the end deliverables to make them as usefull as possible.
For public - Make HEATOX information public available.
Strategies for industry – we could complement the AA toolbox
Restaurants - make information available, but the National authorities have the responsibility in this area to give guidelines to the restaurant.

Flip chart:

1. More insight into food culture
3. Cultural Dependent Food
4. Different strategies to different groups
Industry Strategies

State of the art
It is today agreed that the dominating formation mechanism for acrylamide in food is the reaction of free asparagine with reducing sugars. This reaction is part of the Maillard reaction system (amino acid – sugar reactions), which is of vital importance to quality development (colour, flavour, etc.) during heat processing of many food products. A major challenge for food industry is, therefore, to be able to reduce the acrylamide levels without unacceptably influence other quality aspects.

Research performed and reported on more detailed reaction mechanisms and reaction kinetics forms a basis for applied research and practical experiments on mitigation options. A large amount of such studies have been performed by academia as well as by food industry and there are several examples on resulting successful reduction strategies within industry. The successful solutions are highly product specific, but may be categorized into some common basic principles:

- **Influence on the content of reactants** (asparagine and sugars). This may be done by choice or control of raw materials, pre-treatment (washing etc.), fermentation, enzymatic reactions.
- **Influence of the reaction pathways or the extent of reaction**. This may be done by controlling processing conditions (temperature, time, moisture, pH) or by influencing the “reaction mixture” through recipe or ingredients.
- **Influence on the further fate of acrylamide formed**. This is, so far, a minor option, but it is known that the acrylamide levels may be reduced by increased thermal input (e.g. roasting of coffee). It has also been discussed whether acrylamide may react with other food components.

There are several reports on mitigation studies in the scientific literature and there is a broad range of experience built up within industry. It is generally agreed that there is no single, general solution to reduce the acrylamide levels. The possibilities may even differ within the same food category. The total quality and risk/benefit aspects must always be taken into account and the optimal solution has to be found for each food product.

From this understanding CIAA has developed a “Toolbox” to assist food companies in their efforts to reduce the acrylamide levels in their specific products and processes. The Toolbox gives brief descriptions of mitigation options that have been proposed (by the research community as well as by industry) and in many cases also implemented by food manufacturers. The idea is that this will allow individual food companies to assess and evaluate which interventions steps identified so far may be relevant in their specific cases. The intention from CIAA is that the Toolbox shall be a “living document” with a catalogue of tested concepts that will be updated as new findings are communicated.

Questions to discuss
- Is there anything to add to the state of the art as described above and as presented during the introductory parts of the workshop?
- Is the scientific basis adequate for minimisation strategies within industries, restaurants, etc.?
- Could HEATOX fill any gaps the last six months?
- Is the material available useful as advice to food companies, restaurants, etc.?
- How should HEATOX structure the end deliverable *Manual on strategies to industry and restaurants etc. to minimise acrylamide formation (D60)* in order to make it as useful as possible?
Group 4 – Industry strategies

1. Anything to add to the state of the art?
   - Need to model mitigation studies from a risk/benefit perspective. Model possible impact on exposure vs ‘other’ effects (nutritional, antioxidants...). Could enable goals to be set.

2. Is scientific basis adequate for minimisation strategies?
   - CIAA Toolbox is a very good approach. Need to have two types of monitoring.
     - Monitoring of acrylamide levels by authorities
     - Monitoring of application of Toolbox of and by industry.
   - CIAA Toolbox needs to be translated into different languages and put into a ‘qualitative’ HACCP format, although critical limits cannot be set, rather guidance as to which elements might be critical/worth trying for each product category.
   - Needs to be made available to SMEs

3. Last six months of Heatox?
   - Should bring closely together Heatox scientists, Industry scientists and Govt. Scientists so as to ensure that all available knowledge can be included in the CIAA Toolbox. Simply making information available on the web is not enough, needs proactive approach from Heatox.
   - Avoid duplication
Group 5 – Industry strategies

1. Structure of D60?
   - Background to the problem
   - Understandable language
   - General guidelines & framework
   - “Living” document
   - Estimation of reduction

2. Is the available material useful?
   - More user-friendly
   - Adaptable for different needs and different products

3. Could HEATOX fill any gaps?
   - No scientific
   - Compile the available data
   - Taylor the information for the end user

4. Is the scientific basis adequate?
   - Scale-up problems
   - AA↓ Other compounds? By altering the process to decrease AA, other toxic compounds might on the contrary increase
   - Addition of Asparaginase and other measures to decrease acrylamide formation
   - Consider approach versus economical feasibility

5. Anything to add?
   - Not much to add

Group 5, additional questions:

1. Can industry provide some examples of best practice and corresponding results?
   To be answered

2. Are similar strategies adopted by industry address the EU or do they vary from country to country?
   Answer: Concerted strategy

3. How the CIAA Toolbox reach every food company in every member state?
   Answer: CIAA works with national authorities and professional food associations translating it into national languages etc.

4. How acrylamide as a known hazard could be incorporated in the HACCP system?
   Answer: Difficult, there is no need indeed as CIAA Toolbox is used. But we cannot rely on the colour of the food as golden colour foods found to have high AA levels (comment from the Deep Fryers Industry)
5. Have Deep Fryers Industry made changes to their equipment in order to minimise AA?
   Answer: Yes, but users need to be trained.

6. Any legislative measures taken?
   Answer: In the US idea was rejected → no adequate scientific basis
   In Europe, Switzerland has adopted an “Act” (not compulsory) according to which AA above a limit should be labelled.

7. What is the extent of use of the CIAA Toolbox and what effect is this having on AA levels?
   To be answered

8. Any feedback from CIAA Toolbox use?
   Answer: Yes, constantly, they will be elaborated and put to CIAA website.
The Acrylamide Story

Margareta Törnqvist
Dept. of Environmental Chemistry
Stockholm University

The Acrylamide Story

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Dept. of Environmental Chemistry
Stockholm University

Research line:
Risk estimation of chemical carcinogens

- Most known carcinogenic chemicals which are genotoxic are electrophiles (RX).
- Approach based on experience from radiobiology and radiological protection philosophy.
- Measurement of internal dose of the genotoxic agent as a basis for risk estimation procedures.

How the construction of a railway tunnel through the Hallandsås ridge led to the discovery of acrylamide in food

How measure short-lived electrophiles (RX) in vivo? As stable adducts to Hb in blood

- RX reacts with nucleophilic sites in hemoglobin (Hb) and form adducts.
- Adducts accumulate over the life span of the red blood cells.
- Adducts to N-terminal valine could be specifically detached, isolated, and analysed by mass spectrometry.
- Adduct level: a measure of average dose of RX in blood during preceding months.

Törnqvist et al., Anal. Biochem. 154 (1986) 255

Railway tunnel construction at Hallandsås

Aug 1997: Due to heavy water leakage, use of a grouting agent based on acrylamide.

Hallandsås: An uncontrolled exposure situation

- Ca. 1500 tons grouting agent were used during Aug – Sept 1997.
- End of Sept: Acute situation with fish death and paralysis of cows.
- Leakage of acrylamides: Into rivulets, ground water, wells etc.
- Heavy media coverage and actions by residents in the area.
- Buyers’ resistance to food products (e.g. potato) from this area.
**Hallandsås: How clarify leakage of/exposure to the grouting agent?**

- Chemically reactive and toxic compound.
- Potential exposure of tunnel workers and residents, and of animals.
- Exposure through inhalation, skin and ingestion (food and drinking water).
- Free acrylamide undergoes reactions in the body and are excreted relatively fast (after 2 days less than 1 promille remains).

**Acrylamide**

\[
\begin{array}{c}
\text{H}_2\text{N} \\
\text{C} \\
\text{CH} \\
\text{CH}_2 \\
\text{O} \\
\end{array}
\]

**Chemically reactive and toxic compound.**

**Potential exposure of tunnel workers and residents, and of animals.**

**Exposure through inhalation, skin and ingestion (food and drinking water).**

**Free acrylamide undergoes reactions in the body and are excreted relatively fast (after 2 days less than 1 promille remains).**

**Analysis of blood from animals: Acrylamide cause of fish death and paralysis of cows?**

<table>
<thead>
<tr>
<th>Level of acrylamide adducts (nanomol/g Hb)</th>
<th>Poisoned</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cows</td>
<td>35 - 45</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Rainbow trout</td>
<td>3.9 - 4.6</td>
<td>&lt; 0.0005</td>
</tr>
</tbody>
</table>

*Acrylamide identified as the cause. What about exposure to humans?*

Collab.: J. Härdig, SVA; K. Forslund et al., SLU

**Hallandsås: Hemoglobin adducts from acrylamide and neurotoxic symptoms**

- **Neurotoxic**
- **Dose-response: No-effect threshold**
- **Genotoxic, cancer risk-increasing?**
- **Dose-response: Linear no-threshold**

**Acrylamide**

\[
\begin{array}{c}
\text{H}_2\text{C} \\
\text{H}_2\text{C} \\
\text{O} \\
\text{NH}_2 \\
\end{array}
\]

**Glycidamide**

\[
\begin{array}{c}
\text{H}_2\text{C} \\
\text{CH} \\
\text{NH}_2 \\
\end{array}
\]

**Health risks of acrylamide**

**Measurement of Hb adducts as a tool for assessment of health risks**

- Adduct level in blood
- Reactivity
- Pharmaco-kinetics
- Internal dose and uptake
- Toxic potency
- Risk model
- Health risk

**Hallandsås: Hemoglobin adducts from acrylamide and neurotoxic symptoms**

- **Neurotoxic**
- **Dose-response: No-effect threshold**
- **Genotoxic, cancer risk-increasing?**
- **Dose-response: Linear no-threshold**

**Health risks of acrylamide**

**Measurement of Hb adducts from acrylamide (AA)**

**Adduct level in blood**

- **Non-smokers**
- **Smokers**

**Reactivity Pharmaco-kinetics Internal dose and uptake Toxic potency Risk model Health risk**

**Hallandsås: Hemoglobin adducts from acrylamide and neurotoxic symptoms**

**Adduct level (picomol/g Hb)**

- **Tunnel workers**
- **Controls Residents**

**37 % with mild, reversible symptoms**

**Estimated threshold for effect (10 - 40 µg/kg/day)**

Tunnel workers at Hallandsås: Cancer risk estimation and risk communication

Estimated average life-time cancer risk:
Exposed workers: 30.05%

Comparison with known cancer risks:
Normal background risk: 30 %
Smokers: ~ 40 %

Estimated number of cases among 200 exposed workers:
Background risk: 60 (47 – 74)
Among exposed: 60.1 (47 – 74)

Background level of adduct from acrylamide in unexposed persons? Importance?

If acrylamide was the origin of the adduct signal observed in unexposed persons, this was estimated to correspond to:
- A general, relatively high exposure source of acrylamide.
- A daily uptake of acrylamide of ca. 80 micrograms/person.
- A relatively high cancer risk.

Hypothesis
Adduct level low in wild animals, high in smokers:
Source: Heating of food?

Test: Fried/Unfried feed to rats
Adduct levels in Hb from acrylamide

Formation of acrylamide in food?
In which food could acrylamide be formed?

<table>
<thead>
<tr>
<th>Food Type</th>
<th>No. of Samples</th>
<th>Median (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein-rich foods</td>
<td>5</td>
<td>1740 (1300-3900)</td>
</tr>
<tr>
<td>Carbohydrate-rich foods</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Restaurant-prepared foods etc.</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Restaurant-prepared foods etc.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Restaurant-prepared foods etc.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Restaurant-prepared foods etc.</td>
<td>2</td>
<td></td>
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<td>2</td>
<td></td>
</tr>
<tr>
<td>Restaurant-prepared foods etc.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Restaurant-prepared foods etc.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Restaurant-prepared foods etc.</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

Acrylamide (µg/kg)

Heating temperature and acrylamide formation

<table>
<thead>
<tr>
<th>Temperature (ºC), Duration (min)</th>
<th>Acrylamide formation (µg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120, 15 min</td>
<td>1000</td>
</tr>
<tr>
<td>180, 15 min</td>
<td>1500</td>
</tr>
</tbody>
</table>

Precursors of acrylamide soon identified

Asparagine $\xrightarrow{\Delta}$ Acrylamide

- Acrylamide is formed in the Maillard reaction, with asparagine as dominating precursor.
- High concentrations of asparagine as free amino acid in potato.

Exposure and in vivo doses

- Average intake of AA.
- Internal doses of glycidamide from AA in food?

Cancer risk estimates

- Glycidamide, the major cancer risk-increasing factor?
- Dose-response at low doses?
- Species-extrapolation from rat (cancer tests) to humans?
- Cancer risk model?

(20 x difference in risk coefficient between models)

Intake of acrylamide from food

- Estimated average daily intake in adults:
  ca. 0.5 µg/kg body weight - ca. 35 µg in total1-3
  (preliminary estimate from Hb adducts, 80 µg).
- In Sweden the contribution to the intake is estimated as:
  coffee 40 %, potato products 35 %, bread and cakes 20 %.

Cancer risk from dietary acrylamide: Something to bother about? Preliminary estimates.

The cancer risk is **preliminary** estimated to correspond up to about 1 % of the normal background cancer incidence.

<table>
<thead>
<tr>
<th>Collective risk</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cancer cases per year in Sweden</td>
<td>~ 45 000</td>
</tr>
<tr>
<td>If 1 % contribution from acrylamide in food</td>
<td>~ 500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Individual risk</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average (normal) risk for cancer disease</td>
<td>~ 30 %</td>
</tr>
<tr>
<td>In absence of acrylamide (if 1 % contribution)</td>
<td>~ 29.7 %</td>
</tr>
<tr>
<td>Cf. Hallandsås, exposed workers</td>
<td>~ 30.05 %</td>
</tr>
</tbody>
</table>

Comments

- Exposure to AA in the general population is rather even.
- Most probably it will not be possible to reduce dietary AA to very low levels.
- AA is not the only cancer risk increasing agent formed in heating of food.
- Background exposure observed from many genotoxic compounds, e.g. simple epoxides and aldehydes.
- AA in food is a challenge with regard to cancer risk estimation and with regard to risk communication.

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Eden Tareke, Per Rydberg, SU
Sune Eriksson, Patrik Karlsson, AnalyCen, Lidköping

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Risk model: Lars Ehrenberg, SU, Fredrik Granath, Karolinska Institute
Glycidamide: Birgit Paulsson, SU, Jan Grawe, Uppsala

**Hallandsås study and human dietary study:**
Human studies: Lars Hagmar et al., Lund University, E. Wirfält, Malmö
Animal studies: J. Härdig, SVA, Uppsala
K. Forslund, A.-C. Godin et al., SLU, Uppsala
E. Bergmark, A. Kautiainen, A.-L. Magnusson, SU.
HEATOX Aquarium

- Wendy Matthews (A)
- Angelika Tritscher (R)
- David Lineback (R)
- Gene Rowe (C)
- Barbara Gallani (C)
- Richard Stadler (I)
- Leif Busk (A – H)
- Jacob van Klaveren (R – H)
- Margareta Törnqvist (R – H)

Moderators: Stuart Slorach and Helga Odden Reksnes

Aquarium scene

Aquarium discussion

- an «intelligent» and responsible dialogue among representatives of key stakeholders focusing on important issues of common interest resulting in some sort of consensus statement or a negotiated platform as basis for further work

Aquarium should

- *intensity and focus* the discussion
- enhance responsibility among the stakeholders
- invite the discussants to listen to each other, not confronting every argument with a counterargument or presenting a series of parallel monologues
- result in short statements (agreed (?) upon conclusions and/or statements about disagreements/dilemmas)

Rules

- The supporters are not allowed to interrupt the discussion.
- Written messages can be sent both ways between discussants and their supporters.
- Time outs are possible – can be asked by the discussant, the moderator or co-moderator – this gives the discussant an opportunity to confer with supporters.

Role of moderators

- define time frames and enforce them
- secure attention to given subject
- encourage balanced participation in the discussions
- initiate interaction with supporters
- suggest conclusions agreed or disagreed upon by the group
- write down/up short sentences expressing the views of the group (or fractions)
Aquarium output

General questions for the Aquarium

- Do we have enough data?
  - only enough analytic data on Acrylamide
  - industry: OK
  - homecooking and catering/restaurants: NO
- What are the most important issues/questions HEATOX could focus on during its last six months in order to produce useful guidelines to consumers and minimisation strategies for industry?
  - Homecooking toolbox on Acrylamide to the used for Authorities and consumer org, etc.
    - General recommendations
      - Cultural differences must be considered
      - Generic advice related to all heat-generated food toxicants
    - Critical points related to Acrylamide
  - Comment and add HEATOX data to CIAA Toolbox

Specific questions

- Each discussant was encouraged to raise one relevant issue for the discussion in the Aquarium. Issues raised:
  - Targeting of different audiences
  - Improvement of risk analysis framework
  - Management dilemmas (Leif Busk’s experiment)
  - Consumers eat food, not Acrylamide – how do we advice consumers?
  - How do we judge individual components?
  - Approaches to home cooking
  - Putting risk into perspective –do we have enough data – how should the results be communicated?
  - Quantification of exposure
  - Improvement of risk estimates
The HEATOX project is supported by the European Commission Research Directorate-General within the Sixth Framework Programme's Thematic Priority 5 "Food Quality and Safety". (Contract no Food-CT-2003-506820 Specific Targeted Research Project). The project does not necessarily reflect the Commission’s views or anticipates the Commission’s future policy in this area.

The HEATOX project started on the 1st of November 2003 and has a duration of 40 months.

www.heatox.org