New Approaches to Chemical Risk Assessment

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Introduction to Chemicals in Food

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Food is chemicals

- asparagine
- iron
- starch
- globulin
- phytate
- styrene
- 4-nonylphenol
- cadmium
- folate
- anthocyanins
- albumin
- amylase
- proteinase inhibitor
- oxalic acid
- deltamethrin
- dimethylpyrazine
- lectin
- glyptosate
- cadmium
- isopropylthioxantone
- acrylamide
- propham
- methylbutanal
- furan
- lead
- DDT
- phenylalanine
- ascorbic acid
- lead
- hydroxymethylfurfural
- etc...
Food is chemicals

**Nutrients:**
- Macro (proteins, carbohydrate, lipids)
- Micro (vitamins, minerals)

**Anti-nutritional:**
- reduce digestibility (e.g. protease inh.)
- Reduce bioavailability (phytate)

**Inherent toxicants**
- glycoalkaloids (chaconine, solanine)

**Additives:**
- preservatives
- Antioxidants
- Flavors
- ...

**Agricultural residues:**
- pesticides
- veterinary drugs
- sanitizers/disinfectants
- packaging migrants

**Process contaminants**
- thermal (acrylamide, furan, flavors)
- fermentation
- pH
- ....

**Contaminants**
- Industrial (heavy metals, dioxins, ...)
- Natural (heavy metals, mycotoxins)
Sources of chemicals in food
milk as an example

Agri./vet. Practices:
• antibiotics
• hormones
• agrochemicals

Environment:
• pollutants
• Mycotoxins
• Agrochemicals

Milk production:
• Milking ustensils
• Teat treatments
• Sanitation

Manufacturing:
• Processing
• Packaging

Raw milk

Dairy products

• hormones
• allergens
• ....
Examples of chemicals in food

Pesticides

- Pesticide are widely used in agriculture:
  - Control detrimental organisms:
    - Fungi, insects, rodents, weeds
  - Increase availability of plant foods
- Residues (parent, metabolites) occur in raw materials and finished foods
- 800 active substances
Examples of chemical in food

Packaging migrants

- EU-plastic regulation: >900 substances
- Swiss regulation on inks: 6000 substances
- Belgium database: >10000 substances (monomers, additives, ink comp., adhesives, NIAS...)

Migration into food?

Packaging increasingly seen as source of food contaminations
Examples of chemicals in food

process related contaminants

Asn
Asp
Gln
Glu

Acrylamide
acrylic acid
butenamide
butenoic acid

23 free amino acids → 26 vinylogous compounds

EU-HEATOX → 800 chemicals
Other processes → .....
## Examples of chemicals in food

### inherent toxicants from food plants

<table>
<thead>
<tr>
<th>toxicants</th>
<th>Typical food</th>
<th>Effects (human)</th>
<th>mechanism</th>
<th>structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glycyrrhizin acid</td>
<td>Licorice</td>
<td>Hypokalemia, arrhythmia, hypertension</td>
<td>Inh. rennin-angiotensin-aldosterone</td>
<td></td>
</tr>
<tr>
<td>Linamarin</td>
<td>Cassava</td>
<td>Headache, Neurological, convulsions</td>
<td>Cyanide binding to cytochrome oxidase</td>
<td></td>
</tr>
<tr>
<td>α-solanine</td>
<td>potato</td>
<td>Gastro-intest. Neurological</td>
<td>AChE-inhibition, Disrupt. cell membrane</td>
<td></td>
</tr>
</tbody>
</table>
Examples of chemicals in food
inherent toxicants from non-food plants

200 tropane alkaloids
(musc. ach recept. Inh.)

350 pyrrolizidine alkaloids
(some carcinogenic)

• Present in *datura* seeds
• Impurities in soy beans, millet, buckwheat seeds

• Produced by many plants
• Seeds of such plants may contaminate food/feed
• Transfered in milk
• Found in honey
Examples of chemicals in food

Adulterants/food fraud

• Intentional and economically-motivated adulteration of foods.
• Fraudulent addition of non-authentic substances
• Could (but not necessarily) result in safety issues:
  ➢ Farmed salmon sold as wild
  ➢ Milk adulterated with melamine
Examples of chemicals in food

Melamine in milk

September 2008:

• High volume chemical:
  – Resins for plastics, coatings, laminates, …
  – Flame retardants
  – Glues,
  – Non-protein source of nitrogen
  – …

• Fraudulently added to milk and milk products (infant formulas)

• Artificially enhances the apparent protein content (high in nitrogen)

• Very severe health consequences:
  – > 300000 infants affected (renal symptoms)
  – > 50000 infants hospitalized
  – At least 6 deaths (renal failure)
  – Stones with uric acid (1:1)
  – Cyanuric acid not involved
Food is chemicals:
What the problem?

- Peanut proteins - allergenic
- Vitamin A - teratogenic
- Cadmium - toxic to kidney
- Perchlorate - toxic to thyroid
- Lead - neurobehavioral toxicity
- Aflatoxins - hepatocarcinogenic
- Zearalenone - toxic for reproduction
- Peanut proteins - allergenic
Chemicals produce toxicity
e.g. acute effects

Key words:
- chemical specific
- potency
- natural/artificial
- health impact
- conditions

Water (14000 g)
Ethanol (700g)
Glyphosate (400g)
Salt (250g)

Vitamine A (2g)
Solanin (0.35g)
Parathion (0.14g)

Dioxin (TCDD) (0.00007g)
Botulinum toxin (0.0000007g)
Toxic effects are diverse

- **Acute (fast):**
  - Organophosphorus (respiratory arrest)
  - Allergens (anaphylactic chock)
  - ...

- **Chronic (slow):**
  - Aflatoxin B1 (liver cancer)
  - Cadmium (kidney failure)
  - Cyanide (konzo, neurodegenerative disease)
  - ...

- **Delayed:**
  - Lead (development of nervous system)
  - Vitamin A (teratogenicity)
  - Endocrine disruptors (reproduction)
  - ...

**Key words:**
- chemical specific
- potency
- severity
- time-course
- target organs
- subpopulations
- natural/artificial
Toxicity depends on chemical structure

food mycotoxin zearalenone as example

A, zearalenone (ZEN); B, α-zearalenol (α–ZEL); C, β-zearalenol (β–ZEL); D, α-zearalanol (α–ZAL); E, β-zearalanol (β–ZAL); F, hypothemycin

E2 > αZAL ~ αZOL > βZAL > ZEN > βZOL

Binding = redistribution = transcriptional act. = uterotrophic assay

200x
**Food is chemicals**

**So what the problem?**

**Food is chemicals**

- Sugars, proteins,
- Vitamins, minerals,
- Bioactives,
- Inherent toxicants,
- Acrylamide, furan,
- Additives,
- Pesticides, vet. drugs,
- Heavy metals,
- Mycotoxins

**Chemicals are toxic**

- Carcinogenic,
- Teratogenic,
- Developmental,
- Neurotoxic,
- Reprotoxic,
- Hepatotoxic,
- Endocrine disruptor,
- Behavioral,
- Allergenic,

... Chemicals may compromise food safety, but ....

This is the dose which makes the poison

**Food chemicals must be managed:**

- Assess safety concern (define what is safe or level of risk)
- Management options
Risk assessment-risk management

Problem formulation:
- Definition of the problem to be managed

Risk assessment:
- Scientific opinion

Other information:
- Technical factors
- Cost/benefit
- Perception
- Value judgment

Risk management:
- Decision
- Action plan (definition, execution)
- Verification (impact)
- Improvement
Risk perception

Facts, information

- Scientific evaluation ("fact-based")
- Affect me?
- Distribution: fair-unfair
- Hidden/transparent?
- Unavoidable/avoidable?
- Inescapable/feeling of control
- Natural/artificial
- Commodity versus product
- ...

Perception

(acceptability)
Chemicals in food

Summary & Conclusion

• Food is chemicals.
• Chemicals may compromise food safety.
• Chemicals have to be managed.
• Chemicals to be managed need to be identified.
• Risk assessment is the tool to establish priorities.