Incidents involving contamination of food with dioxins

Martin Rose
What is ‘Contamination’?

- microbiological, chemical or physical hazards
- Specific characteristics of chemical hazards:
  - cumulative low doses
  - delay between exposure and the onset of symptoms
- environmental contaminants include:
  - heavy metals
  - mycotoxins and other natural toxins
  - dioxins, PCBs
  - flame retardants
  - processing contaminants e.g. PAHs
  - veterinary medicines
  - pesticides
Causes

- poor harvesting or storage
- use of banned products
- industrial discharges
- human error
- deliberate adulteration and fraud
Definition of ‘Incident’

• an episodic occurrence of *adverse health effects* in humans (or animals that might be consumed by humans) following high exposure to particular chemicals, or instances where episodically high concentrations of chemical hazards were detected in the food chain, and traced back to a particular event resulting in *major economic loss*
UK Food incidents 2011

**Figure 2: Incidents by category, 2011**

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental contamination</td>
<td>13</td>
</tr>
<tr>
<td>Natural chemical contamination</td>
<td>21</td>
</tr>
<tr>
<td>Microbiological contamination</td>
<td>14</td>
</tr>
<tr>
<td>On-farm</td>
<td>11</td>
</tr>
<tr>
<td>Labelling / documentation</td>
<td>10</td>
</tr>
<tr>
<td>Allergens</td>
<td>11</td>
</tr>
<tr>
<td>Pesticides</td>
<td>13</td>
</tr>
<tr>
<td>Physical contamination</td>
<td>10</td>
</tr>
<tr>
<td>Use of an unauthorised ingredient</td>
<td>10</td>
</tr>
<tr>
<td>Veterinary medicines</td>
<td>11</td>
</tr>
<tr>
<td>Food contact materials</td>
<td>10</td>
</tr>
<tr>
<td>Animal feed (on market)</td>
<td>10</td>
</tr>
<tr>
<td>Counterfeit product</td>
<td>10</td>
</tr>
<tr>
<td>TSE</td>
<td>10</td>
</tr>
<tr>
<td>Illegal import / export</td>
<td>10</td>
</tr>
<tr>
<td>Radiological</td>
<td>10</td>
</tr>
<tr>
<td>Process contaminants</td>
<td>10</td>
</tr>
<tr>
<td>Irradiated ingredient</td>
<td>10</td>
</tr>
<tr>
<td>Water quality</td>
<td>10</td>
</tr>
<tr>
<td>Biocides</td>
<td>10</td>
</tr>
</tbody>
</table>

**Table 5: Environmental contamination incidents by sub category, 2011**

<table>
<thead>
<tr>
<th>Environmental contamination</th>
<th>Number of incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fires (potential PAH issues)</td>
<td>235</td>
</tr>
<tr>
<td>Sewage</td>
<td>33</td>
</tr>
<tr>
<td>Heavy metal (geophysical)</td>
<td>26</td>
</tr>
<tr>
<td>Inorganic spills</td>
<td>19</td>
</tr>
<tr>
<td>Gas leaks</td>
<td>14</td>
</tr>
<tr>
<td>Organic spills</td>
<td>11</td>
</tr>
<tr>
<td>Diesel spills</td>
<td>4</td>
</tr>
<tr>
<td>Oil spills</td>
<td>3</td>
</tr>
<tr>
<td>Dioxins and polychlorinated biphenyls (PCB’s)</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>356</strong></td>
</tr>
</tbody>
</table>
Incidents with dioxins and dioxin-like PCBs

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Source</th>
<th>Highest levels</th>
<th>Discovered by</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>1957</td>
<td>Feed fat, cow hides, chlorophenols</td>
<td></td>
<td>Effects, authorities</td>
</tr>
<tr>
<td>US</td>
<td>1969</td>
<td>Water, chlorophenols</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>1968</td>
<td>Rice oil; PCB-oil</td>
<td></td>
<td>Effects</td>
</tr>
<tr>
<td>Taiwan</td>
<td>1979</td>
<td>Rice oil; PCB-oil</td>
<td></td>
<td>Effects</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1989</td>
<td>Waste incinerators</td>
<td>Grass, milk</td>
<td>University?</td>
</tr>
<tr>
<td>US</td>
<td>1996</td>
<td>Ball clay, feed, chickens, cat fish</td>
<td></td>
<td>Authorities</td>
</tr>
<tr>
<td>Germany</td>
<td>1998</td>
<td>Brazilian citrus pulp, lime, PVC</td>
<td>Pulp, milk</td>
<td>Authorities</td>
</tr>
<tr>
<td>Belgium</td>
<td>1999</td>
<td>Feed fat, PCB-oil</td>
<td>Feed, eggs, chicken meat, pork</td>
<td>Effects, private</td>
</tr>
<tr>
<td>Switzerland/Austria</td>
<td>1999</td>
<td>Kaolinic clay</td>
<td>Clay, pork</td>
<td>Authorities</td>
</tr>
<tr>
<td>Germany</td>
<td>2000</td>
<td>Choline chloride, sawdust, PCP</td>
<td></td>
<td>Authorities</td>
</tr>
<tr>
<td>Germany</td>
<td>2003</td>
<td>Dried bakery waste, waste wood</td>
<td></td>
<td>Fresenius (private or authorities?)</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2004</td>
<td>Potato peels, kaolinic clay</td>
<td>Milk, 20</td>
<td>Private</td>
</tr>
<tr>
<td>Italy</td>
<td>2004</td>
<td>PCP in wood shavings used as litter</td>
<td>Poultry, meat eggs</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td>2006</td>
<td>Feed fat, gelatin, HCl</td>
<td>Feed fat, 400</td>
<td>Authorities</td>
</tr>
<tr>
<td>Italy</td>
<td>2008</td>
<td>Mozzarella, waste incineration</td>
<td>Mozzarella</td>
<td>Authorities?</td>
</tr>
<tr>
<td>Italy</td>
<td>2008</td>
<td>Wood shavings, PCP</td>
<td>Wood shavings</td>
<td>Authorities</td>
</tr>
<tr>
<td>Switzerland</td>
<td>2007</td>
<td>Guar gum</td>
<td>Guar gum 480</td>
<td>Private</td>
</tr>
<tr>
<td>Chile</td>
<td>2008</td>
<td>Feed, zinc oxide</td>
<td>Zinc oxide, pork</td>
<td>Authorities</td>
</tr>
<tr>
<td>Ireland</td>
<td>2008</td>
<td>Dried bakery waste, PCBs in fuel</td>
<td>Bakery waste, Pork, 600, Beef, 1000, pig liver, 16000</td>
<td>Private, authorities</td>
</tr>
<tr>
<td>Netherlands/Germany</td>
<td>2010</td>
<td>Organic corn, unknown</td>
<td>Corn 2.5; feed, eggs</td>
<td>Private, authorities</td>
</tr>
<tr>
<td>Germany</td>
<td>2010</td>
<td>Industrial fatty acids, chlorophenols</td>
<td>Feed, up to 1.5; eggs, meat</td>
<td>Private</td>
</tr>
</tbody>
</table>
‘Chicken-gate’

- Belgium 1999
- Dioxins (in fact 50 kg PCBs with 1 g dioxins) resulted in chicks unable to hatch
- PCB transformer oil was added directly to 500 tonnes animal feed
- >2500 poultry and pig farms affected
- About 60,000 PCB or dioxins analysis performed that year
- Direct cost to Belgian economy ~ €1.5–2 billion
The crisis

- Economy/brand – all Belgian food subject to embargo – US bans import of all poultry and pork from all of Europe!
- Politics – Belgian Ministers for Agriculture and Public Health resigned
- Scare – high toxicity – poorly understood – exaggerated perception of risk
- Media - Belgian authorities portrayed as protecting farmers’ and meat industry ahead of public health
Consequences

- Belgian national limits for 7 marker PCBs in feed and food established in 1999 for animal feed, chicken and pork

- 2002 - EU limits for PCDD/Fs in animal feed and food of animal origin (EEC, 466/2001)

- Dioxin-like PCBs were included in 2006 (EEC, 199/2006)
Tolerable intakes

1980s and 1990s – various TDIs set (range 1 – 10 pg/kg bw)

WHO consultation (1998): TDI of 1- 4 pg WHO-TEQ/kg bw --> target to achieve 1 pg WHO TEQ /kg bw

EU Scientific Committee for Food (May 2001): TWI of 14 pg WHO-TEQ/kg bw

JECFA (June 2001): TMI of 70 pg WHO-TEQ/kg bw

UK TDI (October 2001): 2 pg WHO-TEQ/kg bw
How were limits set?

- About 1/3 population exceeded TDI
- Priority to reduce overall intake
- Limits set to exclude most highly contaminated products from entering food chain
Maximum and Action levels

Position of peak makes most difference for chronic exposure.

The peak is shifting left as a result of pollution control measures.

Enforcement of limits removes the right tail.

Maximum level

Action level
Maximum levels

- Strict but feasible
- Regulatory control
- Uniform application (within EU)
Action levels

• An ‘early warning’ tool - Lower than maximum levels
• trigger action to identify sources and pathways of contamination
• A pro-active approach to reduce the presence of dioxins in food and feed
• interact with environmental and other control measures
Target limits

- indicate the levels to be achieved over time (feed and food) in order to ultimately bring human exposure for the majority of the EU population down to or below the TWI.
- Target levels were to be established before the end of 2004, but are still not set.
Risk

- Enforcement of limits does not implicitly significantly reduce risk or improve food safety (unless an EXTREMELY highly contaminated product is found)

BUT....

- They do increase the amount of monitoring that is undertaken

WHICH RESULTS IN....

- Increase in the number of incidents that are uncovered

How many go un-noticed?
When limits are exceeded

- Ireland 2008
- Pork meat contained several hundred times the limit
  - 6-7% pig farms affected
  - ~ 3 months

EFSA concluded risk to health was low
Food incident?

Victor Yuschenko, former president of Ukraine
Analytical methodology

- 1990s – EPA 1613 – primarily for wastewater and environmental samples – later used for foods;
- EU regulations gave analytical performance criteria specifically for food control
Standard methods

Prescribing a specific method of analysis means:

• The analyst is denied freedom of choice and thus may be required to use an inappropriate method in some situations;
• The procedure inhibits the use of automation;
• It is administratively difficult to change a method found to be unsatisfactory or inferior to another currently available.

But......

• Easier for the analyst!
• Has been used in Codex and EU
Criteria approach

• gives greater flexibility than the present procedure adopted by organisations such as Codex and the EU

• avoids the situation of having many methods of analysis available, which meet requirements as regards method performance characteristics, but which are not considered by Codex or the EU because of time constraints.

Specified criteria tend to be:

LOD; LOQ; Precision; Recovery; Selectivity
‘Fitness-for-purpose’ Approach (Uncertainty Function) Approach

• Where a limited number of methods of analysis exist, a ‘fitness-for-purpose’ approach may be used to assess the suitability of the method of analysis.

• Methods suitable for official control must produce results with standard measurement uncertainties less than the maximum standard measurement uncertainty calculated using the formula:
‘Fitness-for-purpose’ Approach (Uncertainty Function Approach)

\[ U_f = \sqrt{\left(\frac{CL}{2}\right)^2 + (aC)^2} \]

where:
- \( U_f \) is the maximum standard uncertainty
- CL is the detection limit of the method
- C is the concentration of interest
- \( a \) is a numeric factor to be used depending on the value of C.

<table>
<thead>
<tr>
<th>C (µg/kg)</th>
<th>a</th>
</tr>
</thead>
<tbody>
<tr>
<td>( a \leq 50 )</td>
<td>0.25</td>
</tr>
<tr>
<td>1 to 500</td>
<td>0.18</td>
</tr>
<tr>
<td>501 to 1,000</td>
<td>0.15</td>
</tr>
<tr>
<td>1,001 to 10,000</td>
<td>0.12</td>
</tr>
<tr>
<td>&gt; 10,000</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Results with an uncertainty less than that stipulated above will be produced by a method which is equivalent to one meeting specified performance characteristics.
Standardisation

Method

Single Lab Validation Provider

Third Party Validation Provider or ICC, AACC, etc.

Approved Standard ICC, AACC, etc.

ISO/CEN Standard

Can take 4-5 years (at least!)

Idea
Research

Company
Performance tested
First results
Repeatability

Performance data
Fit for purpose
Ring trial
Min. 8 laboratories
Repeatability
Reproducibility

Official protocol
Legal value
National law
International trade
Caution!!

When standard methods become available there is a danger that:

• They are set in regulations
• They are demanded by industry
• They result in a stagnation of technology

But....

Reliable

Useful for non-specialist labs
CEN method for dioxins

• Fera, RIKILT and EU-RL

Whichever methods are used, analytical uncertainty should be calculated.
Uncertainty

- Analytical results have an associated uncertainty
- This must be taken into account before action is taken

This can be calculated with a reasonable confidence

- There is also uncertainty relating to sampling, intake estimates, effects of cooking etc.

This can have a larger impact!
Screening or non-validated methods

• May not have full validation data
• May not meet analytical criteria

• But still may help in times of crisis – especially if rapid and able to differentiate between ‘contaminated’ and ‘clean’ samples
Monitoring and official control

- Requirement established under the EU General Food Law
- The two are often confused
- Official control subject of subsequent regulations (882/2004 and 1883/2006)
- Monitoring subject of recommendations (2006/88/EC)
Official control in the EU

- Regular audit of food and feed operators
- ‘appropriate frequency’
- Risk based (past record of food operators)
- Coordinated between national, regional and local bodies
- National control plan and annual reporting
- Not explicit in detail eg sample types and numbers
Monitoring (EU)

- ‘planned sequence of observations or measurements with a view of obtaining an overview of the state of compliance with food and feed law’ (Regulation 882/2004, article 2, L165/21).
- Use to establish population risk (not to target non-compliance)
- In 2006 minimum monitoring requirement was specified as 2000 samples for EU-27 and EFTA.
Compliance

• No reliable information
• No standard reporting (despite obligation to report)
• But results of monitoring are collated by EFSA
Effectiveness of regulation

- EFSA Report: ‘Results of the monitoring of dioxin levels in food and feed’

*EFSA Journal 2010 8 (3):1385*

Total of 7270 samples analysed 1999-2008 by 19 EU Member States, (+ Norway and Iceland)
EFSA Report

- Highest mean levels for dioxins and dl-PCBs (a) in liver and products thereof from terrestrial animals (fat wt) and (b) fish liver and products thereof (whole weight)
- For feed, highest levels in fish oil
- 8 % exceeded maximum limits
- Additional 4 % exceeded some action limits

...BUT

- Some of the samples originated from targeted sampling, eg in contamination incidents (not random monitoring) – introduces further uncertainty and bias
Overall impact of a decade of monitoring?

• Difficult to assess - confounders
• Different samples analysed in different years
• Changes in diet - therefore exposure
• Changes in EU MS (new countries join)
• Advances in analytical methods
• Differences in LoD / LoQ
• Inclusion of dl-PCBs
List of Incidents

• Please add to the Wikipedia page

List of food contamination incidents
http://en.wikipedia.org/wiki/List_of_food_contamination_incidents
Thank you for your attention