The First Hong Kong Total Diet Study Report No. 3: Polybrominated Diphenyl Ethers (PBDEs)
Total Diet Study (TDS)

- A tool for estimating dietary exposure, one of the steps in risk assessment
  - Involves food sampling and preparation, laboratory analysis, dietary exposure estimation
- Internationally recognised
  - Most cost effective way to estimate the dietary exposure of various population to a range of chemicals or nutrients
- Provide scientific basis for assessing food safety risks and regulating food supply
TDS Differs from Food Surveillance Programme

- Focus on substances in the **whole diet**, not on individual foods
- Prepare foods as **table-ready form**
- Take into consideration the impact of cooking
- Assess dietary exposure to **substances actually ingested** by the population, rather than concentrations of substances in food
Objectives

- To estimate dietary exposures of the Hong Kong population and various population subgroups to a range of substances, including contaminants and nutrients
- To assess any associated health risks
Study Reports

- 1st: Dioxins and dioxin-like PCBs
- 2nd: Inorganic Arsenic
- 3rd: Polybrominated Diphenyl Ethers (PBDEs)
Reasons to Study PBDEs

- Widespread and persistent in the environment and potentially toxic to humans
- Were found increasing in human bodies
- Received increasing attention by international health authorities because of their potential to impact upon human health and the environment
- Research from Baptist University found fish sold from HK market contained high levels of PBDEs and the exposure to PBDEs by the local population caused concern
PBDEs

- A group of industrial chemicals—flame retardants
  - Plastics, polyurethane foam, and textiles
- 3 main commercial products
  - PentaBDE, OctaBDE and DecaBDE
- PentaBDE and OctaBDE
  - POPs (persistent organic pollutants) under the Stockholm Convention in 2009
Properties

- Lipophilic
- Persistence in the environment
- Accumulate in living organisms through the food chain
Sources

- At low levels in air, water, soil, sediments, indoor dust and food

- Indoor air, indoor dust and food, including human milk are the main sources of human exposure
Sources in Food

- Fatty foods of animal origin
  - Some fish, meats and dairy products

- Food processing related sources
  - Food contact with PBDE containing packaging materials may result in elevated contamination of food (EFSA 2011)
Toxicity

- In general, the lower the bromination of the PBDE, the higher the toxicity (e.g. PentaBDE is more toxic than DecaBDE)

Animal studies

- Low Acute toxicity
- Chronic toxicity
  - Cause liver enlargement
  - Affect the development, particularly on the brain and the reproductive organs
  - Affect neurobehavioural development
  - Disrupt thyroid hormone levels
Toxicity (2)

- Genotoxicity
  - Majority studies: not genotoxic

- Carcinogenicity
  - IARC classification
    - DecaBDE: Group 3 agent, i.e. not classifiable as to its carcinogenicity to human
    - PentaBDE & OctaBDE: no evaluation
Toxicity (3)

Human data

- Epidemiological studies indicated
  - An association between exposure to PBDEs and altered thyroid hormone regulation

- EFSA 2011
  - Observed effects not always consistent
  - Other coexisting contaminants could have confounded the outcome
Margin of Exposure (MOE)

- The Joint Food and Agriculture Organization (FAO)/World Health Organization (WHO) Expert Committee on Food Additives (JECFA)
  - Available data on PBDEs were not adequate for allocating a safety reference value
  - For the more toxic [less brominated] PBDE congeners, adverse effects would be unlikely to occur in rodents at dose <100 µg/kg bw/day
  - International estimate of dietary intake: ~4 ng/kg bw /day
  - Margin of Exposure (MOE) = 25 000 (large MOE)
  - The larger the MOE, the lower the health concern
Methods

- **Samples**
  - 426 samples (collected on 2 occasions, each occasion 71 food items, each item 3 samples)
  - 3 samples from the same food item collected in each occasion were combined into one sample, \(\rightarrow\) a total of 142 composite sample were analysed

- **Tested substances**
  - 24 PBDE congeners

- **Dietary exposure estimation**
  - Performed by an in-house developed web-based computer system, EASY
    - Mean average dietary exposure
    - 95th percentile exposure for high consumers
Results
## PBDE Contents

<table>
<thead>
<tr>
<th>Food Group</th>
<th>No.</th>
<th>Mean (pg/g) [range]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggs and their products</td>
<td>6</td>
<td>1693.7 [124.7-8401.9]</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>4</td>
<td>1031.6 [58.4-2060.1]</td>
</tr>
<tr>
<td>Confectioneries</td>
<td>2</td>
<td>525.7 [444.8-606.7]</td>
</tr>
<tr>
<td>Fish and seafood and their products</td>
<td>38</td>
<td>350.4 [15.4-2421.5]</td>
</tr>
<tr>
<td>Meat, poultry and game and their products</td>
<td>24</td>
<td>191.9 [37.6-791.0]</td>
</tr>
<tr>
<td>Cereals and their products</td>
<td>24</td>
<td>172.5 [11.8-776.9]</td>
</tr>
<tr>
<td>Mixed dishes</td>
<td>22</td>
<td>92.2 [5.6-340.1]</td>
</tr>
<tr>
<td>Vegetables and their products</td>
<td>2</td>
<td>74.2 [51.4-97.0]</td>
</tr>
<tr>
<td>Snack foods</td>
<td>2</td>
<td>62.2 [52.7-71.7]</td>
</tr>
<tr>
<td>Dairy products</td>
<td>10</td>
<td>43.0 [6.3-180.1]</td>
</tr>
<tr>
<td>Condiments, sauces and herbs</td>
<td>2</td>
<td>18.7 [14.2-23.3]</td>
</tr>
<tr>
<td>Beverages, non-alcoholic</td>
<td>6</td>
<td>11.6 [6.5-21.2]</td>
</tr>
</tbody>
</table>
## PBDE Contents (2)

<table>
<thead>
<tr>
<th>Food items</th>
<th>Mean (pg/g) [range]</th>
<th>Compare to international data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salted egg</td>
<td>4562.2 [722.5-8401.9]</td>
<td>NA</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>1962.7 [1865.3-2060.1]</td>
<td>Comparable</td>
</tr>
<tr>
<td>Yellow croaker</td>
<td>1632.8 [844.1-2421.5]</td>
<td>Comparable</td>
</tr>
</tbody>
</table>
Dietary Exposure

- Average consumers: 1.34 ng/kg bw/day
- High Consumers: 2.90 ng/kg bw/day
Dietary Exposures to PBDEs of Different Age-gender Groups

International Exposure estimated by JECFA 2005
Food Groups Contributing to Total Dietary Exposure to PBDEs

- Fish and seafood and their products: 27.3%
- Meat, poultry and game and their products: 20.7%
- Cereal and their products: 15.9%
- Fats and oils: 15.9%
- Mixed dishes: 15.9%
- Eggs and their products: 9.2%
- Beverages, non-alcoholic: 6.9%
- Condiments, sauces and herbs: 1.6%
- Dairy products: 0.8%
- Confectioneries: 0.4%
- Vegetables and their products: 0.2%
- Snack foods: 0.1%
## Comparison with Other Places

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>PBDE exposure from dietary sources (ng/kg bw/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium</td>
<td>2007</td>
<td>Upper bound 0.80  Lower bound 0.38</td>
</tr>
<tr>
<td>Japan</td>
<td>2008</td>
<td>Lower bound 1.1</td>
</tr>
<tr>
<td>USA</td>
<td>2006</td>
<td>0.9-1.2</td>
</tr>
<tr>
<td>Spain</td>
<td>2003</td>
<td>1.2-1.4</td>
</tr>
<tr>
<td>Spain</td>
<td>2008</td>
<td>1.1</td>
</tr>
<tr>
<td>HK</td>
<td>2012</td>
<td>1.34-2.90</td>
</tr>
<tr>
<td>UK</td>
<td>2006</td>
<td>Upper bound 5.91</td>
</tr>
<tr>
<td>Australia</td>
<td>2007</td>
<td>Upper bound 49-132  Middle bound 25-67  Lower bound 1-4</td>
</tr>
</tbody>
</table>
Be Cautious When Making Comparison

- No. of congeners tested
  - The more the congeners tested, the higher the PBDEs levels and dietary exposure calculated
- Limit of detection (LOD)
- Treatments of LOD values (upper bound vs lower bound)
- Types of food tested
- Consumption patterns
Limitations

- Small number of samples was analysed
  - 2 out of 4 occasions
- Only food likely to contain PBDEs were selected for testing
  - 71 out of 150 food items
  - May lead to under-estimation
Conclusion

- Dietary exposure to PBDEs
  - Average consumer: 1.34 ng/kg bw/day
  - High consumer: 2.90 ng/kg bw/day
- Large MOE values → health concern is low. Dietary exposure of the population was unlikely to be a significant health concern
Advice to Trade

- Try to reduce the amount of fat in food products (e.g. select lean cuts of meat and poultry, use low-fat dairy products, use low-fat cooking methods, etc)
- Obtain food supplies from reliable sources
- Maintain proper records to enable source tracing when required
Advice to Public

- Maintain a balanced diet so as to avoid excessive exposure to chemical contaminants from a small range of food items
- Consume low-fat products, trim fat from meat and meat products
- To prepare food with less amount of fats and oils
The End