The First Hong Kong Total Diet Study: Mycotoxins

18 December 2013

The 1st HKTDS

- First time carrying out in HK
- Period: 2010-2014
- Objectives:
  - To estimate the dietary exposures of the HK population and various population subgroups to a range of substances, including contaminants and nutrients
  - To assess any associated health risks

The 1st HKTDS (2)

- **Food consumption data**
  - Data from Hong Kong Population-Based Food Consumption Survey (FCS) 2005-2007 was used for exposure analysis
- **Cover 150 food items and over 130 substances**
  - Pesticide residues, POPs, metallic contaminants, mycotoxins, macro nutrients, elements, etc.
  - Analysed in table-ready form
- **Reports released**

1. Dioxins and Dioxin-like Polychlorinated Biphenyls (PCBs)
2. Inorganic Arsenic
3. Polybrominated Diphenyl Ethers (PBDEs)
4. Pesticide Residues
5. Metallic Contaminants
6. Acrylamide

The 7th Report: Mycotoxins

- Diet is the main source of exposure to common mycotoxins for ordinary adults
- Chronic toxicity is the main concern for general population in Hong Kong

Scope

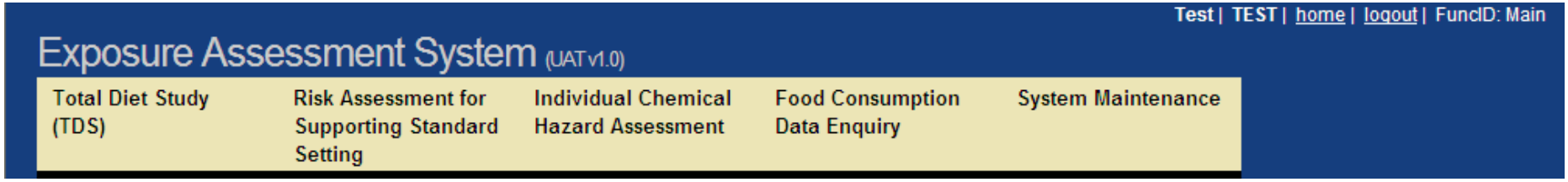
1. Aflatoxins (AFs)
2. Ochratoxin A (OTA)
3. Fumonisins (FUMs)
4. Deoxynivalenol (DON) and acetyldeoxynivalenols (AcDONs)
5. Zearalenone (ZEA)

Methodology

- **Food sampling and preparation:** 4 occasions from March 2010 to February 2011
  - Samples were collected and prepared as consumed (table-ready)
  - A total of 1800 samples were collected and combined into 600 composite samples
- **Laboratory Analysis:** by the Food Research Laboratory (FRL)
  - Mycotoxins: 720 individual samples combined into 240 composite samples of 60 food items (mainly foods of plant origin)

Dietary Exposure Estimation

- Perform with the aid of an in-house developed web-based computer system called “EASY” (Exposure Assessment System)
- Involve food mapping and weighting of data
- Average: mean exposure level
- High consumer: 95th percentile of exposure level



Aflatoxins

- Potent mutagenic & carcinogenic substances
- Role in human liver cancer, especially for people who has hepatitis B antigen
- International Agency for Research on Cancer (IARC) (2002) classified naturally occurring aflatoxins as “carcinogenic to humans” (Group 1 agents)
- JECFA (1997): intake should be reduced to as low as reasonably possible

Regulatory Levels

- Harmful Substances in Food Regulations (Cap. 132AF)
- Specified maximum levels of total aflatoxins in food
  - Maximum 20 micrograms per kilogram of the food for peanuts and peanut products
  - Maximum 15 micrograms per kilogram of the food for any food other than peanut or its products

Previous Study

- Aflatoxins in Food, 2001
- Scope: Food that might contain aflatoxins (e.g. peaunts & its products, vegetable oils & fats, cereal & cereal products)
- Based on food surveillance data 1998 - 2000
- Results were compared against the statutory limits and that only one peanut butter sample out of 526 samples were found to exceed the regulatory limit
- Limitation: population exposure levels were not estimated

Concentrations of Aflatoxins in TDS Foods

- 96% samples not detected (LOD = 0.05 µg/kg)
- The highest aflatoxins level for *food group*: "Legumes, nuts and seeds and their products" (mean: 1.34 – 1.50 µg/kg (Lower bound (LB) – Upper bound (UB))

Concentrations of Aflatoxins in TDS Foods (2)

Food Items	Mean (µg/kg)		Maximum (µg/kg)
	LB	UB	UB
1. Peanut butter	6.3	6.4	14
2. Peanut	1.6	1.8	5.5
3. Chinese pastries	0.83	0.94	1.4

* The assumption “ND = 0” is used for lower bound (LB) figures and “ND = LOD” is used for upper bound (UB) figures.

Dietary Exposure to Aflatoxins of Average and High Consumers

	Average	High Consumer
Dietary Exposure (μg/kg bw/day)	**0.0002 – 0.0028**	**0.0009 – 0.0049**

No health based guidance values had been assigned by JECFA. JECFA recommended that intake should be reduced to as low as reasonably possible.

Cereals and their products are the major food contributors to aflatoxins exposure.

Aflatoxins and liver cancer

- With reference to the aflatoxins intake and the rate of hepatitis B, it is estimated that aflatoxins caused approximately 8 cases in Hong Kong.
- It is estimated that aflatoxins contribute to less than 1% of liver cancer cases in Hong Kong based on 2010 incident rate

Comparison of Dietary Exposure to Aflatoxins

Places	Dietary exposure of adults (μg/kg bw/day)	
	Average	High Consumer
France (2011)	0.000886	0.001537
Hong Kong	0.0002 – 0.0028	0.0009 – 0.0049
China (2007)	0.01109	0.4131
Ireland (2011)	0.003 – 0.018	0.006 – 0.039

Ochratoxin A (OTA)

- Toxic to kidneys
- IARC (1993) classified ochratoxin A as possibly carcinogenic to humans) (Group 2B agent)
- JECFA (2001) established a Provisional Tolerable Weekly Intake (PTWI) of 0.1 μg/kg bw/week to ochratoxin A

Previous Study

- "Ochratoxin A in Food", 2006
- Dietary exposure of average and high consumers of the secondary school students were 0.00388 and 0.00897 μg/kg bw/week respectively.
- Both well below the PTWI of 0.1 μg/kg bw/week
- Concluded that consumers of the secondary school students were unlikely to experience major toxicological effects of OTA

Concentrations of Ochratoxin A in TDS Foods

- 80% samples not detected (LOD=0.05 μg/kg)
- The highest ochratoxin A level for food group: “Sugars and confectionary” (mean: 0.22 μg/kg)

Concentrations of Ochratoxin A in TDS Foods (2)

Food Items	Mean (μg/kg)		Maximum (μg/kg)
	LB	UB	UB
1. Breakfast cereals	0.36	0.38	0.85
2. Chocolate	0.22	0.22	0.31
3. Fermented bean products	0.17	0.19	0.55

Dietary Exposure to Ochratoxin A of Average and High Consumers

	Average	High Consumer
Dietary Exposure (μg/kg bw/week)	**0.0013 – 0.0054**	**0.0036 – 0.0092**
% PTWI	**1.3 – 5.4 %**	**3.6 – 9.2 %**

PTWI: 0.1 μg/kg bw/week

Cereals and their products are the major food contributors to ochratoxin A exposure.

Comparison of Dietary Exposures to Ochratoxin A

Places	Dietary exposure of adult (μg/kg bw/week)	
	Average	High Consumer
Hong Kong	0.0013 – 0.0054	0.0036 – 0.0092
France (2011)	0.00196 – 0.01337	0.00427 – 0.02261
Ireland (2011)	0.0014 – 0.028	0.0063 – 0.070

Fumonisins

- Fumonisin B_1 (FB1) targets liver and kidneys in animal studies
- IARC (1993): classified toxins derived from *Fusarium moniliforme* (e.g. FB1, FB2) as possibly carcinogenic to humans (Group 2B agents)
- JECFA (2010): established a Provisional Maximum Tolerable Daily Intake (PMTDI) of 2 μg/kg bw for the sum of FB1, FB2 and FB3

Concentrations of Fumonisins in TDS Foods

- 98.2% samples not detected (LOD=2.5 μg/kg)
- The highest fumonisins level for food group: “Cereals and their products” (mean: 2.58 – 9.76 μg/kg (LB – UB))

Concentrations of Fumonisins in TDS Foods (2)

Food Items	Mean (μg/kg)		Maximum (μg/kg)
	LB	UB	UB
1. Breakfast cereals	49	50	120
2. Cornstarch	3.1	9.3	15
3. Potato chips	0.98	7.9	8.9

Dietary Exposures to Fumonisins of Average and High Consumers

	Average	High Consumer
Dietary Exposure (μg/kg bw/day)	**0.0016 – 0.0973**	**0.0008 – 0.1692**
% PMTDI	**0.08 – 4.9 %**	**0.04 – 8.5 %**

PMTDI: 2 μg/kg bw/day for FUMs (sum of FB1, FB2 and FB3)

Cereals and their products are the major food contributors to fumonisins exposures.

A Comparison of Dietary Exposures to Fumonisins

	Dietary exposure of adults (μg/kg bw/day)	
	Average	High Consumer
France (2011)	0.00989 – 0.0449	0.0325 – 0.1011
Hong Kong	0.0016 – 0.0973	0.0008 – 0.1692

Deoxynivalenol (DON)

- Feed refusal and vomiting in animal studies. Possible co-effect between DON and triclothecenes and zearalenone in maize had been suggested.
- IARC (1993) classified toxins derived from from *Fusarium graminearum*, *F. culmorum* and *F. crookwellense*: zearalenone, deoxynivalenol, nivalenol and fusarenone X as not classifiable as to their carcinogenicity to humans (Group 3 agents)
- JECFA (2010): Group provisional maximum tolerable daily intake (PMTDI) 1 μg/kg bw for DON and its acetylated derivatives (i.e. AcDON)

Concentrations of DON and AcDON in TDS Foods

- 83.1% samples not detected (LOD = 2.5μg/kg)
- The highest DON and AcDON level for food groups: “Cereals and their products” (mean: 29.95 – 33.11 μg/kg (LB - UB))

Concentrations of DON and AcDON in TDS Foods (2)

Food Items	Mean (μg/kg)		Maximum (μg/kg)
	LB	UB	UB
1. Biscuits	180	180	480
2. Breakfast cereals	60	62	110
3. Steamed barbecued pork bun	56	58	80

Dietary Exposures to DON and AcDON of Average and High Consumers

	Average	High Consumer
Dietary Exposure (μg/kg bw/day)	**0.0861 – 0.1426**	**0.2166 – 0.2824**
% PMTDI	**8.6 – 14.3 %**	**21.7 – 28.2 %**

PMTDI: 1 μg/kg bw/day

Cereals and their products are the major food contributors to DON and AcDON exposures.

A Comparison of Dietary Exposures to DON and AcDON

Places	Dietary exposure of adult (μg/kg bw/day)	
	Average	High Consumer
Belgium (2013)	0.1162	0.4047
Hong Kong	0.0861 – 0.1426	0.2166 – 0.2824
China (2005)	0.1488	0.8785
France (2011)	0.373 – 0.411	0.716 – 0.768

Zearalenone (ZEA)

- ZEA have non-steroidal estrogenic activities
- Cause acute toxicity in pigs – vulva vaginitis and enlarged reproductive tracts
- May affect reproduction in a long term studies in female pigs
- IARC (1993) concluded that ZEA has limited carcinogenicity in experimental animals (Group 3 agent)
- JECFA (2000) established a Provisional Maximum Tolerable Daily Intake (PMTDI) of 0.5 μg/kg bw/day to ZEA

Concentrations of ZEA in TDS Foods

- 97% samples not detected (LOD = 2.5 μg/kg)
- The highest ZEA level for food group: “Fats and oils” (mean: 48.75 – 53.75 μg/kg (LB - UB))

Concentrations of ZEA in TDS Foods (2)

Food Items	Mean (μg/kg)		Maximum (μg/kg)
	LB	UB	UB
1. Vegetable oil	49	54	120
2. Chocolate	15	18	20
3. Cornstarch	5.0	10	13

Dietary Exposures to ZEA of Average and High Consumers

	Average	High Consumer
Dietary Exposure (μg/kg bw/day)	**0.0061 – 0.1015**	**0.0166 – 0.1724**
% PMTDI	**1.2 – 20.3 %**	**3.3 – 34.5 %**

PMTDI: 0.5 μg/kg bw/day

Cereals and their products are the major food contributors to zearalenone exposures.

Comparison of Dietary Exposures to ZEA

Places	Dietary exposure of adult (μg/kg bw/day)	
	Average	High Consumer
France (2011)	0.0059 - 0.0255	0.0108 - 0.0425
Belgium (2013)	0.0447	0.1568
Hong Kong	0.0061 – 0.1015	0.0166 – 0.1724

A Summary of Estimated Dietary Exposures to Mycotoxins of the Hong Kong Adult Population

Contaminant	Health Based Guidance Value	Estimated Dietary Exposures# (% Contribution to Health Based Guidance Value)	
		Average Consumers	High Consumers
Aflatoxins	NA (Intake as low as reasonably possible)	0.0002 – 0.0028 µg/kg bw/day (NA)	0.0009 – 0.0049 µg/kg bw/day (NA)
Ochratoxin A	PTWI: 0.1 µg/kg bw	0.0013 – 0.0054 µg/kg bw/week (1.3 – 5.4 % PTWI)	0.0036 – 0.0092 µg/kg bw/week (3.6 – 9.2 % PTWI)
Fumonisins	PMTDI: 2 µg/kg bw	0.0016 – 0.0973 µg/kg bw/day (0.08 – 4.9 % PMTDI)	0.0008 – 0.1692 µg/kg bw/day (0.04 – 8.5 % PMTDI)
Deoxynivalenol & acetyl-deoxynivalenols	PMTDI: 1 µg/kg bw	0.0861 – 0.1426 µg/kg bw/day (8.6 – 14.3 % PMTDI)	0.2166 – 0.2824 µg/kg bw/day (21.7 – 28.2 % PMTDI)
Zearalenone	PMTDI: 0.5 µg/kg bw	0.0061 – 0.1015 µg/kg bw/day (1.2 – 20.3 % PMTDI)	0.0166 – 0.1724 µg/kg bw/day (3.3 – 34.5 % PMTDI)

The exposure is presented as a range, where the assumption “ND = 0” is used for lower bound (LB) figures and “ND = LOD” is used for upper bound (UB) figures

Summary of Findings

- All dietary exposure estimates for were below their available health based guidance values, where available for four of the mycotoxins
- Aflatoxins are estimated to contribute to less than 1% of liver cancer cases in Hong Kong

Conclusions

- The general adult population was unlikely to experience major undesirable health effects of the mycotoxins

Recommendations - Advice to the Public

- Purchase from reliable retailers.
- Store cereals and grains products and nuts properly in cool dry places.
- Maintain a balanced and varied diet as to avoid excessive exposure to mycotoxins from a small range of food items.
- Look out for the durability and expiration date of food.
- Discard foods that look mouldy or damaged.
- Since nuts contain many nutrients, such as unsaturated fatty acids, high quality protein, fibre, vitamins, minerals etc, people may include unsalted nuts as part of a well-balanced diet and consume unsalted nuts in moderation.

Recommendations - Advice to the Trade

- Observe good agricultural practices and good manufacturing practices/HACCP to minimize mycotoxin contamination of foods.
- Obtain food materials from reliable suppliers.
- Maintain good storage conditions. Store food in cool and dry places and rotate stock on a first-in-first-out basis.
- Maintain proper records to enable source tracing when required.

The End