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Extended Abstract (4 X A4 pages)

EXPOSURE ASSESSMENT OF POLYCHLORINATED DIBENZO-*P*-DIOXINS, POLYCHLORINATED DIBENZOFURANS AND DIOXIN-LIKE POLYCHLORINATED BIPHENYLS IN SEAFOOD SAMPLES AMONGST ADULT POPULATION IN MALAYSIA

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Introduction

Polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are collectively designated as dioxins. Dioxins and dioxin-like polychlorinated biphenyls (dl-PCBs) are highly toxic and belong to a group of chemically and structurally related halogenated aromatic hydrocarbons. According to the International Agency for Research on Cancer (IARC), there are 210 theoretical possible congeners of PCDD/Fs, of which 17 show the same toxicology pathway with the most toxic 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD). In contrast, of the 209 PCBs congeners, 12 show toxicological properties similar to that of PCDD/Fs¹ and therefore are often termed dl-PCBs. These 17 PCDD/Fs and 12 dl-PCBs congeners have been identified by the World Health Organization (WHO) as prioritized contaminants and are recommended for regular monitoring².

Dioxins and PCBs are unwanted by-products formed via incomplete combustion, such as waste incineration, forest fires and some industrial processes³. In the past, PCBs have been produced and used in dielectric fluids in transformers, capacitors, and other electrical equipments⁴. Both the dioxins and PCBs are persistent organic pollutants (POPs) and have adverse impacts on human health. These contaminants can induce severe toxic effects, including carcinogenicity, immunotoxicity, and a range of endocrine effects related to reproductive function⁵. In the strategy to decrease human exposure to PCDD/Fs and PCBs, the European Commission (EC) has introduced maximum levels for PCDD/Fs and dl-PCBs in various food groups via Commission Regulation (EC) No. 1881/2006⁶. WHO has set a tolerable daily intake (TDI) for the sum of PCDD/F-TEQ and dl-PCB-TEQ of 1–4 pg TEQ kg⁻¹body weight⁷, which is comparable with a tolerable weekly intake of 14 pg TEQ kg⁻¹ body weight as fixed by the European Union Scientific Committee on Food⁸.

Due to the high lipophilicity and low biodegradability properties, dioxins and PCBs tend to accumulate in the food chain, particularly in animal fat⁹. It is estimated that more than 90% of exposure to these contaminants for general population originates from foods¹⁰. In recent years, a number of studies on the occurrence of dioxins and PCBs in various food samples and the human exposure estimation have been reported in several countries over the world^{5,11-16}. In this paper, we investigate the level of dioxins and PCBs in seafood samples from Malaysia and estimate the human intake.

Materials and methods

A total of 145 seafood samples including fish, prawn, squid, dried anchovy, and other processed seafood products were collected in 2012 in Malaysia. In this study, a variety of fish species, such as tilapia, grouper, pomfret, barramundi, horse mackerel, and snapper, were investigated. Processed seafood products were referred to canned sardine, canned crab meat, fish ball, octopus ball, tempura seafood, and crab stick.

All reagents used were of analytical grade. Extraction of PCDD/Fs and dl-PCBs from seafood samples was adopted from United States Environmental Protection Agency (USEPA) Method 3545, using a Dionex ASE 350 accelerated solvent extractor (ASE) device. Clean-up process through a series of multilayer silica, alumina, and carbon columns, was performed using Power-Prep Fluid Management System. The clean-up procedure was derived from the Smith–Stallings method outlined in USEPA Method 8290. High-Resolution Gas

Chromatography/High-Resolution Mass Spectrometry (HRGC/HRMS) was used for PCDD/Fs and dl-PCBs analysis following the USEPA Methods 23, 1613, and 8290.

Deterministic method for chronic exposure as reported by Dorne et al¹⁷ was used for the calculation of dietary intakes of PCDD/F and PCB. In the formula, daily food consumption was multiplied by the corresponding concentration and divided by average adult body weight. Food consumption data from Malaysian food-consumption statistics¹⁸ were used in the exposure estimation. An average body weight of 60 kg for adults was taken for the purpose of estimating dietary intake.

Results and discussion:

All of the results were calculated using the 2005 WHO-TEFs¹⁹ and reported on a fresh-weight (fw) basis. Results showed that the concentration of PCDD/Fs ranged from 0.13 to 1.03 pg TEQ g⁻¹ fw (mean 0.16) while dl-PCBs ranged from 0.34 to 0.44 pg TEQ g⁻¹ fw (mean 0.36) (Table 1). The average sum of PCDD/F and dl-PCBs in the seafood samples was 2.577 pg TEQ g⁻¹ fw. Mean exposure to PCDD/Fs and PCBs (in pg TEQ kg⁻¹ body weight day⁻¹) was assessed to be 0.333 and 0.643, respectively in the adult population. It was observed that women were exposed to higher contaminants level compared to men (Table 2). However, the dietary exposure estimations were much lower than the tolerable daily intake (TDI) as recommended by the WHO.

Table 1 WHO₂₀₀₅-TEQ (pg g⁻¹ fw) for PCDD/Fs and dl-PCBs analysis in seafood samples

Samples	PCDD/Fs (pg TEQ g ⁻¹ fw)*	dl-PCBs (pg TEQ g ⁻¹ fw)*
Prawn	0.153 (0.13-0.26) (n=20)	0.353 (0.35-0.39) (n=34)
Squid	0.156 (0.13-0.24) (n=9)	0.348 (0.34-0.35) (n=11)
Fish [#]	0.201 (0.13-1.03) (n=19)	0.354 (0.35-0.36) (n=13)
Processed seafood	0.147 (0.13-0.31) (n=11)	0.362 (0.35-0.44) (n=17)
Dried anchovy	0.141 (0.13-0.16) (n=4)	0.362 (0.35-0.39) (n=7)
Total	0.798	1.779
Sum of PCDD/F and PCBs	2.577	

*Results presented as mean in upper bound value and range in parentheses

[#]Total daily consumption of freshwater and marine fish

Table 2 Estimated dietary intake of PCDD/Fs and dl-PCBs in seafood samples for men and women

Samples	Daily consumption		Intake (pg TEQ kg ⁻¹ body weight day ⁻¹)			
	(g/day)		PCDD/F		dl-PCBs	
	Men	Women	Men	Women	Men	Women
Prawn	2.93	3.07	0.007	0.008	0.015	0.019
Squid	19.56	17.60	0.046	0.047	0.102	0.106
Fish	73.80	71.66	0.221	0.248	0.390	0.437
Processed seafood	21.58	19.29	0.047	0.049	0.117	0.120
Dried anchovy	4.92	4.89	0.010	0.012	0.027	0.031
Total			0.331	0.365	0.650	0.713

Average body weight of 67 kg (men) and 58 kg (women) was used for the calculation

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