Estimating Dietary Exposure of PCDDs/Fs and Co-PCBs in Korea and Risk Assessment

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Introduction

Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDDs/Fs) and polychlorinated biphenyls (PCBs) are present in all compartments of the environment - atmospheric, aquatic, and terrestrial[1]. When they are released into the air, some fractions of PCDDs/Fs are transported to long distances, even around the globe. Exposure routes to PCDDs/Fs and PCBs are known to be as follows ; eating food which contains PCDDs/Fs and PCBs, breathing air, drinking water and skin contact and human main exposure predominantly occurs through the diet with food from animal origin being the major source[1,2]. Therefore, human exposure pattern to PCDDs/Fs can be influenced by habit of food consumption.

The most usual method of assessing average dietary intake is to multiply the average consumption of each type of food by the average concentrations found in corresponding food samples, and then add together the contributions from various components of the diet.

The major effects of PCDDs/Fs and PCBs include dermal toxicity, immunotoxicity, reproductive/developmental effects and carcinogenicity. The Korea Food and Drug Administration (KFDA) has suggested the national Tolerable Daily Intake (TDI) of 2,3,7,8-TCDD as 4pg/kg/day based on reproductive/developmental toxicity through review of revised WHO TDI[3].

This study was conducted to estimate dietary exposure of PCDDs/Fs and Co-PCBs using food monitoring data which was recently investigated and to identify that its exposure are safe whether or not through comparing with TDI of the KFDA.

PCDDs/Fs and Co-PCBs Levels in Foods

PCDDs/Fs and Co-PCBs levels in food were collected from the national surveys implemented by the KFDA (1999, 2000)[4,5]. Total 18 foods including cereal, vegetable, meat, egg, fish and dairy products as foods which are most commonly consumed by the general Korean were selected in this study. All food sample had been collected randomly from food markets in several sites (5 cities) for representative nationwide monitoring as composite sampling.

PCDDs/Fs and Co-PCBs levels were converted into TEQ using WHO_{98}-TEF[6] in this estimation and N.D. assumed to zero.

The residue levels of PCDDs/Fs and Co-PCBs in food were listed in Table 1 in terms of means, variability and sample sizes. On a whole weight basis, TEQ ranged from 0.000~0.180 pg TEQ/g for the grain and vegetable, 0.000~9.642 pg TEQ/g for the fish, 0.000~0.237 pg TEQ/g for the dairy products, and 0.000~0.163 pg TEQ/g for the meat and egg.

Co-PCBs levels in fish and egg were approximately two or four fold higher than PCDDs/Fs levels. PCDDs/Fs levels were higher than Co-PCBs levels in other foods (Table1).

Table 1. PCDDs/Fs and Co-PCBs Levels in Food

	Foods	years	Sample No.	Mean±S.D. (Min. ~Max.)		
				PCDD/Fs	Co-PCBs	PCDD/Fs+Co-PCBs
Grain and Vege table (pg TEQ/g)	Rice	1999,2000	10	0.011±0.014(0.000~0.038)	0.000±0.000(0.000~0.000)	0.011±0.014(0.000~0.038)
	Barley	1999	5	0.021±0.023(0.000~0.063)	0.000±0.000(0.000~0.001)	0.021±0.023(0.000~0.063)
	Soybean	1999,2000	12	0.013±0.014(0.000~0.045)	0.001±0.003(0.000~0.012)	0.014±0.015(0.000~0.045)
	Korean C abbage	1999	5	0.046±0.070(0.000~0.180)	0.000±0.000(0.000~0.000)	0.046±0.070(0.000~0.180)
	Radish	1999	5	0.001±0.001(0.000~0.003)	0.000±0.000(0.000~0.000)	0.001±0.001(0.000~0.003)
Meat (pg TEQ/g)	Beef	1999,2000	14	0.075±0.089(0.001~0.280)	0.026±0.038(0.000~0.134)	0.101±0.109(0.001~0.344)
	Pork	1999,2000	14	0.033±0.040(0.001~0.148)	0.003±0.005(0.000~0.019)	0.036±0.041(0.002~0.151)
	Chicken	1999,2000	10	0.101±0.013(0.000~0.032)	0.013±0.012(0.001~0.034)	0.023±0.024(0.001~0.061)
	Egg	1999,2000	10	0.023±0.025(0.000~0.087)	0.037±0.035(0.001~0.094)	0.060±0.055(0.001~0.163)
Fish (pg TEQ/g)	Pollack	1999	10	0.011±0.011(0.000~0.025)	0.000±0.000(0.000~0.000)	0.011±0.011(0.000~0.025)
	Mackerel	1999,2000	5	0.464±0.505(0.000~1.388)	0.748±0.880(0.000~2.636)	1.213±1.345(0.000~3.850)
	Croaker	1999,2000	10	0.037±0.036(0.000~0.110)	0.104±0.157(0.000~0.476)	0.141±0.169(0.000~0.560)
	Hair tail	2000	5	1.452±1.008(0.021~2.938)	3.760±2.069(0.418~6.704)	5.211±3.066(0.439~9.642)
	Squid	1999	5	0.033±0.027(0.002~0.070)	0.280±0.560(0.000~1.400)	0.313±0.579(0.003~1.470)
	Oyster	2000	5	0.147±0.092(0.002~0.274)	0.183±0.100(0.004~0.259)	0.331±0.119(0.171~0.531)
	Clam	2000	15	0.137±0.325(0.000~1.226)	0.200±0.377(0.000~1.188)	0.336±0.690(0.000~2.414)
Dairy Product (pg TEQ/g)	Milk	1999	2	0.023±0.017(0.006~0.040)	0.001±0.000(0.000~0.001)	0.024±0.017(0.007~0.040)
	Cheese	1999	2	0.018±0.018(0.000~0.036)	0.151±0.050(0.101~0.201)	0.169±0.068(0.101~0.237)

*Detection limit : 0.01ppt

Estimating Dietary Exposure of PCDDs/Fs and Co-PCBs

The estimating dietary exposure were intended to be representative of the general public. T he general Korean adult group, with 60kg as mean of man and woman, was regarded as t he target population, and the data obtained from the National Health and Nutrition Survey (MHW, 1999)[7] were used as mean food consumption data for the individuals.
The general equation used to estimate dietary exposure levels as follows ;

<Background exposure levels>

$$= \sum_{i=1}^{n} \frac{\text{concentration of food}_i \times \text{ingestion rate}_i}{\text{body weight}}$$

- concentration of food i : average TEQ (PCDDs/Fs and Co-PCBs) levels in the foo d I to which individuals are exposed
- ingestion rate : adult mean in 20~64 years supported by National Health and Nutri tion Survey[7]
- body weight : adult mean as 60 kg by Korea Research Institute of Standards and Sciences[8]

Table 2. Dietary Exposure Levels and Contribution of PCDDs/Fs and Co-PCBs

Foods	Ingestion rate (g/day)[1)]	PCDD/Fs		Co-PCBs		PCDD/Fs+Co-PCBs	
		Exposure level (pg/kg/day)	% of total	Exposure level (pg/kg/day)	% of total	Exposure level (pg/kg/day)	% of total
Rice	263.97	0.047	16.2	0.000	0.0	0.047	7.2
Barley	4.30	0.002	0.5	0.000	0.0	0.002	0.2
Soybean	3.57	0.001	0.3	0.000	0.0	0.001	0.1
Korean Cabbage	14.87	0.011	3.9	0.000	0.0	0.011	1.7
Radish	48.27	0.001	0.4	0.000	0.0	0.001	0.2
Grain & Vegetable	**334.97**	**0.062**	**21.3**	**0.000**	**0.0**	**0.062**	**9.5**
Beef	29.40	0.037	12.8	0.013	3.5	0.050	7.6
Pork	30.03	0.016	5.7	0.002	0.4	0.018	2.8
Chicken	8.93	0.002	0.5	0.002	0.5	0.003	0.5
Egg	20.23	0.008	2.7	0.012	3.5	0.020	3.1
Meat & Egg	**88.60**	**0.063**	**21.7**	**0.028**	**7.9**	**0.091**	**14.0**
Pollark	7.90	0.001	0.5	0.000	0.0	0.001	0.2
Mackerel	7.97	0.062	21.3	0.099	27.5	0.161	24.7
Croaker	4.57	0.003	1.0	0.008	2.2	0.011	1.6
Hair tail	2.73	0.066	22.8	0.171	47.4	0.237	36.5
Squid	7.50	0.004	1.4	0.035	9.7	0.039	6.0
Oyster	1.17	0.003	1.0	0.004	1.0	0.006	1.0
Clam	4.17	0.009	3.3	0.014	3.8	0.023	3.6
Fish	**36.00**	**0.148**	**51.3**	**0.331**	**91.5**	**0.479**	**73.7**
Milk	42.40	0.016	5.6	0.000	0.1	0.017	2.6
Cheese	0.53	0.000	0.1	0.001	0.4	0.001	0.2
Dairy products	**42.93**	**0.016**	**5.7**	**0.002**	**0.5**	**0.018**	**2.8**
Total	**502.5**	**0.289**	**100.0**	**0.362**	**100.0**	**0.651**	**100.0**

[1)]Adult mean in 20-64 yrs supported by National Health and Nutrition Survey, 1999

Adult dietary intake of PCDDs/Fs and Co-PCBs were estimated to average 0.651 pg TEQ-WHO_{98}/kg/day.

Daily intake was estimated by combining exposure levels of individual foods. Food group data was used as mean of mean to the regarded individual food.

Table 2 summarizes the exposure level, ingestion rates and resulting intake estimates and il

lustrates the derivation of a dietary exposure levels to PCDDs/Fs and Co-PCBs for Korea.

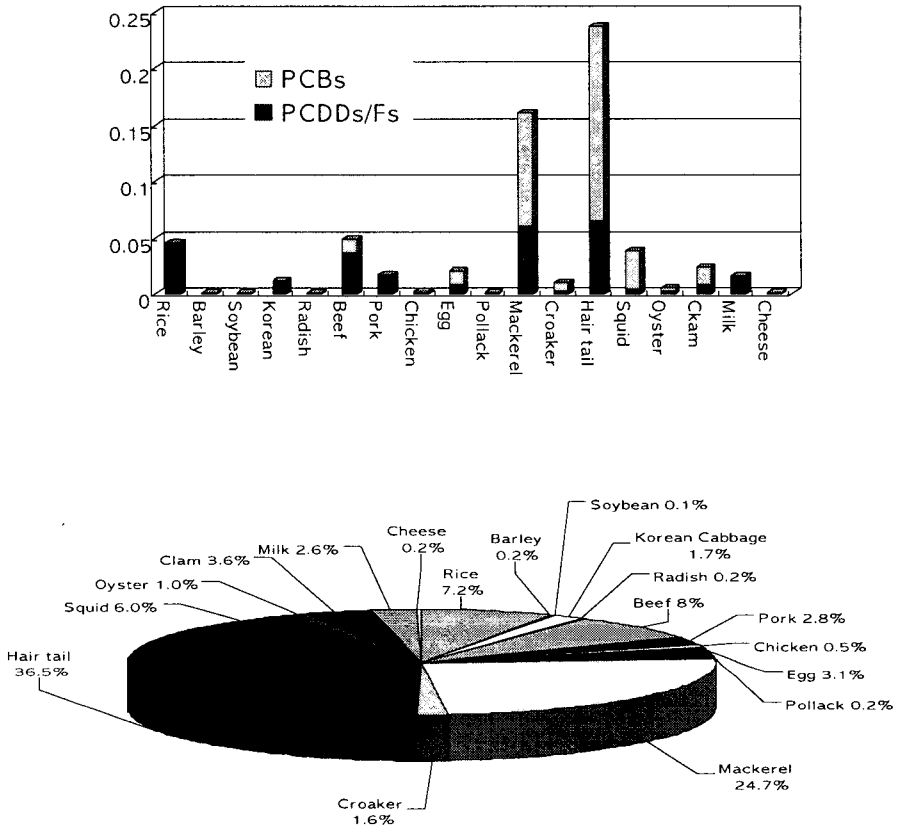

Figure 1. Exposure Contribution of PCDDs/Fs and Co-PCBs in Food

The daily dietary exposure of Co-PCBs was 1.5 fold more higher than that of PCDDs/Fs. Among the individual food, hair tail contributed the greatest exposure (36.5%) to the total dietary exposure levels of PCDDs/Fs and Co-PCBs.

The greatest contributed food to PCDDs/Fs and Co-PCBs was fish as 51.3 % and 91.5%, respectively. The order of high exposure contribution to the total exposure was fish> meat > grain & vegetable> dairy products (Fig. 1). This feature of Korean dietary exposure le vels of PCDDs/Fs and Co-PCBs may be caused by that the ingestion rate of cereal, veget

able and fish is higher than meat and dairy product.

Risk Assessment

When the daily dietary exposure level of PCDDs/Fs and Co-PCBs was compared with Kor ean TDI 4pg/kg/day, hazard index was induced as 0.163. Then, we can suggest that the occurrence of the reproductive/developmental toxicity due to current dietary exposure of P CDDs/Fs and Co-PCBs, would not be expected. If other foods which has not been includ ed in this study are regarded, daily dietary exposure level can be more increased.

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