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Distribution and exposure assessment of indicator PCBs in Food

Keum Soon Oh★, Junghyuck Suh, Ok Jin Paek, Seongsoo Park, Youngjoon Na, Yeong-Sun An, Meehye Kim and Kwang-Ho Lee

Korea Food & Drug Administration 194 Tongil-ro, Eunpyong-gu, Seoul, 122-704, Korea

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식품 중 indicator PCBs의 분포와 노출평가

오금순★ · 서정혁 · 백옥진 · 박성수 · 나영준 · 안영순 · 김미혜 · 이광호

식품의약품안전청

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Abstract: Seven indicator PCBs (IUPAC nos 28, 52, 101, 118, 138, 153, 180 congeners) concentrations were measured in food samples including cereal (polished rice), meats, eggs, milk and dairy products, and fisheries and products as representation for the general Korean populations during 2006-2007, and was analyzed using isotopic dilution method. Fishes had the highest average level as 39.8 ng/g, 1.4 ng/g for milk and dairy products, and 0.9 ng/g for meats. The hairtail out of fishes was contaminated at the level of 15.4 ng/g, 5.4 ng/g for pacific mackerel and spanish mackerel, and 4.5 ng/g for yellow croaker. The ratio for indicator PCBs in overall food was contributed as follows; 35.8% for PCB-153, 16.2% for PCB-138, 16.1% for PCB-101, 13.4% for PCB-118, 8.8% for PCB-180, 6.9% for PCB-52, and 2.9% for PCB-28. The hexa-CBs including PCB-153 and 138 were more predominated, and the next was penta-CBs including PCB-101 and 118 in food. For estimated daily intake (EDI) in average and 95th percentile, fishes and products out of overall food were taken to represent over 50%. However, it was estimated that there was no adverse health effect for Korean.

요 약: 7개 indicator PCBs (IUPAC nos 28, 52, 101, 118, 138, 153, 180)는 2006년부터 2007년까지 한국인의 대표식품을 중심으로 곡류(백미), 육류, 알류, 우유와 유가공품, 수산물 및 그 가공품을 대상으로 동위원소희석법을 이용하여 분석하였다. 모든 식품들 중 어류(평균 39.8 ng/g)에서 가장 높게 검출되었고, 그 다음으로 우유 및 유가공품 (1.4 ng/g), 육류 (0.9 ng/g)이였다. 어류 중 갈치 15.4 ng/g, 삼치 5.4 ng/g, 조기 4.5 ng/g 및 고등어 4.4 ng/g가 검출되었다. 모든 식품에서 indicator PCBs의 비율은 PCB-153 35.8%, PCB-138 16.2%, PCB-101 16.1%, PCB-118 13.4%, PCB-180 8.8%, PCB-52 6.9% 및 PCB-28 2.9% 이었다. PCB-153과 138은 hexa-CB로서 분포가 가장 많았고, 다음으로는 penta-CB인 PCB-101과 118 이었다. 식품을 통한 indicator PCBs에 의한 인체의 평균 및 극단 노출량은 수산물 및 그 가공품이 50%를 차지하였다. 그러나 이 수준은 한국인의 건강에 위해를 끼치지 않은 수준으로 평가되었다.

Key words: indicator PCBs, congeners, isotopic dilution method, estimated daily intake (EDI), food

★ Corresponding author
Phone : +82-(0)2-380-1733 Fax : +82-(0)2-388-6392
E-mail : puregold@kfda.go.kr

1. Introduction

Polychlorinated Biphenyls (PCBs) are synthetic chemicals first introduced in 1929 and subsequently used in various industries. Due to their stability, persistence, and lipophilicity, they have accumulated in the environment and have been bioaccumulated in the lipophilic parts of the food chain. Although their production and use were banned in many countries in the late 1970s, they are still ubiquitously present as a complex mixture in the environment and thus continue to be a source of exposure to the human population.[1] PCBs are a family of compounds which include 209 congeners with dioxin-like toxicity (the non-ortho and the mono-ortho PCBs; DL-PCBs) and congeners with non-dioxin-like toxicity (the di-ortho PCBs; NDL-PCBs).[2] Measurement programs have focused mostly on dioxins in environment and food. However, Many studies reported about non-dioxin-like congeners, showing their ability to induce neurological and behavior alterations in animals.[1-3] Baars *et al*.[4] referred to the waste disposal, both of housed-holds and industrial wastes, is the major source of PCBs emissions into the environment.

The dietary intake of the environmental contaminants, such as dioxin and PCBs for human is estimated to account for greater than 90%. It has been reported that meat, dairy products, such as milk and cheese etc., and fish make up more than 90% of the intake of dioxins and PCBs for the generation population.[5] So, the accumulation of persistent chemicals in human body is of great concern since many of these compounds may be exposed adverse health effects on humans. Park *et al.* (2007) reported that human serum has been exposed to PCBs mainly penta-, hexa-, and heptachlorinated biphenyls (about more than 80%). European Food Safety Agency (EFSA, 2005) noted that the sum of the six indicator PCB represents about 50% of total NDL-PCB in food, and PCB 138 and 153, both with seven chlorine atoms, show the highest carry-over into milk and eggs, in the order of 50-60%. And congeners-specific analysis indicated that PCB congeners (153, 138, 180, 187, and 118) were contributed 57.3% of the total PCBs detected in human serum samples, and it was mainly indicator PCBs excepted PCB 187. The mono-ortho PCB group with dioxin-like activity was represented by PCB 118 and di-ortho PCBs with no reported dioxin activity were 28, 52, 101, 138, 153 and 180. As the congener PCB 118 has also a dioxin-like activity and therefore belongs also to the dioxin-like PCB, it is not always analyzed together with the other 6 indicator PCB. So, Germany and EFSA have applied the six indicator PCBs excepted PCB 118, but the Netherland and China used the seven indicator PCBs.[6]

European Union regulates dioxins (PCDDs/PCDFs) and DL-PCBs in food, and Republic of Korea regulates dioxins (PCDDs/PCDFs) in meats (beef, pork and chicken) setting maximum limits (MLs), but other countries don't have the maximum limits (MLs).[7,8] However, some countries such as USA FDA,[9] Japan,[10] and Food Standard Australia New Zealand (FSANZ)[11] regulate total PCBs as peak pattern method in food, but China set the MLs for indicator PCBs (7 congeners) in marine as 2,000 ng/g[12] because the indicator PCBs have provided a contamination image.

In the present study, it has selected food containing various cereal (polished rice), meats, dairy products, eggs, fish and products, which has taken in mainly by Korean, and was analyzed for seven indicator PCBs out of 209 PCBs using isotopic dilution method. Based on the measured PCB levels (sum of 7 congeners), the assessment exposure to indicator PCBs was done in order to estimate health risk for Korean.

2. Material and Methods

2.1. Material

A total of 137 samples including rice (polished), meats (beef; lean beef ribs, pork; fatback, chicken; meat), milk and dairy products (milk, cheese), eggs (york, only), and fishes (eating parts removed head, tail, internal organ, bone etc.) and products (dried anchovy, canned tuna) were collected as the forms which were sold in Korean retail markets from 5 major cities (Seoul, Busan, Gwangju, Daejeon and

Gangneung) during 2 years (2006-2007). The samples were grounded using the stainless steel blender in order to obtain consistent homogeneity and stored in the deep freezer (-25 °C) until analysis.

2.2. Reagents

The calibration standard (EC-4058+EC-1435 and EC-5179+PCB-118-CS), surrogate (EC-5179+PCB-118-CS), precision and recovery standard (EC-4058+EC-1435 for indicator PCBs) and internal standard (13C-2,2',6-TCB, 13C-2,3',4',5-TeCB, 13C-2,3,4,4'5-PeCB, 13C-2,3',4,4',5,5'-HxCB, 13C-2,2',3,3',4,4',5-HpCB) were purchased from Cambridge Isotope Laboratories (Andover, MA, USA) and extraction solvents which include dichloromethane (DCM) and hexane were purchased from Sigma-Aldrich Co. (Seoul, Korea).

2.3. Preparation of samples

The preparation of samples for indicator PCBs analysis in foods was conducted with modification of USA EPA method[13] using isotopic dilution method.

2.3.1. Extraction

About 5 g of each sample was taken, mixed with 35 g of sodium sulfate (Anhydrous), and transferred to a 66 mL of ASE cell. The samples were then fortified with the ^{13}C-labeled standards (25 μL of EC-4058+EC-1435 for indicator PCBs), and the control samples were fortified with the ^{13}C-labeled standards (25 μL of 250 ng/mL of EC-5179+PCB-118-CS standard) and extracted with Accelerated Solvent Extraction System (ASE) using a mixture of 50% hexane/dichloromethane (v/v). The ASE operating conditions for indicator PCBs analysis was conducted as described in *Table* 2 like Suh *et al.*'s method.[14] For milk, about 10 g of milk sample was taken, mixed with 0.2 g of potassium oxalate, and 10 mL of water (distilled water) and 10 mL of acetonitrile, and then homogenized for 30 min, and passed to C_{18}-cartridge, and dried for 90 min and eluted with 30 mL of n-hexane.

2.3.2. Clean-up

The purified samples were fortified with the C^{13}-

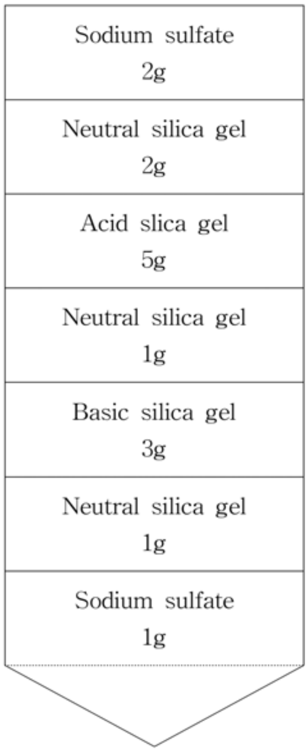

Fig. 1. Preparation of multi-layer column chromatography for analysis of indicator PCBs.

labeled internal standards (^{13}C-2,2',6-TCB, ^{13}C-2,3',4',5-TeCB, ^{13}C-2,3,4,4'5-PeCB, ^{13}C-2,3',4,4',5,5'-HxCB, ^{13}C-2,2',3,3',4,4',5-HpCB, ISTD) and concentrated using the nitrogen evaporator prior to analysis by GC/MS. During extraction and clean up of samples, care has to be taken to avoid losses of the lower chlorinated PCB congeners due to their relative high volatility (*Fig.* 1).

2.4. GC/MS determination

The analysis of indicator PCBs was performed on a GC/MS using isotopic dilution method. The GC and MS consisted of HP6890 (Agilent 5973N, Agilent Technologies, Palo Alto, California, USA) and 5973N (Agilent 5973N, Agilent Technologies, Palo Alto, California, USA). The column was DB-5MS column (30 m × 0.25 mm, 0.1 μm), and carrier gas was helium and flow rate was 1.0 mL/min. Program temperatures: 100 °C hold for 0.2 min, temperature increase of 15 °C/min to 200 °C hold for

Table 1. List of indicator PCBs for analysis and recovery

Congeners	IUPAC Number	m/z			Theoretical ratio	Recovery (%) (n=3)
		M^+	$(M+2)^+$	$(M+4)^+$		
Trichlorobiphenyl	28	256.0	258.0		1.02	97.0±0.8
	28L*	268.0	270.0			
Tetrachlorobiphenyl	52	289.9	291.9		0.77	96.0±0.9
	52L*	301.9	303.9			
Pentachlorobiphenyl	101		325.9	327.9	1.53	95.6±0.9
	118					97.1±1.2
	101L*		337.9	339.9		
	118L*					
Hexachlorobiphenyl	138		359.8	361.8	1.23	94.5±1.0
	153					95.4±1.0
	138L*		371.8	373.8		
	153L*					
Heptachlorobiphenyl	180		393.8	395.8	1.02	97.8±2.2
	180L*		405.8	407.8		

*L : Labelled compound

3 min, increase of 2 °C/min to 220 °C hold for 8 min, increase of 1 °C/min to 230 °C hold for 4 min, increase of 2 °C/min to 250 °C hold for 5 min, increase of 12 °C/min to 300 °C, and 300 °C hold for 3 min.

The injector was set at 280 °C, and the transfer line and ion source were set at 280 °C and 230 °C, respectively. Volume of injected samples was 1 μL, and quantification was carried out on the basis of the selected ionization monitoring (SIM) with 5 window (*Table* 1). The calibration curve was made using EC-4058+EC-1435 and EC-5179+PCB-118-CS and surrogate (EC-5179+PCB-118-CS).

2.7. Assessment of dietary exposure to indicator PCBs

The estimated daily intake (EDI) to indicator PCBs was calculated based on contaminated PCBs data and the consumption of each food reported by Ministry of Health and Welfare in 2005.[15]

3. Results and Discussion

3.1. The level of contamination for indicator PCBs in foods

Regarding PCB 118 of indicator PCBs, EC had excluded it because of its high toxicity described PCB 118 as dioxin-like PCBs, but several countries including Japan and China and European Union etc, considered PCB 118 as indicator PCB. In the study, indicator PCBs were investigated. Recoveries of indicator PCBs from spiked oil material were 97.0±0.8% for PCB-28, 96.0±.9% for PCB-52, 95.6±0.9% for PCB-101, 97.1±1.2% for PCB-118, 94.5±1.0% for PCB-138, 95.4±1.0% for PCB-153, and 97.8±2.2% for PCB-180, respectively (*Table* 1).

Table 2. The instrumental condition of ASE for indicator PCBs extraction

Parameter	Condition
Heat	5 min
Pressure	1500 psi
Static time	5 min
Temperature	100 °C
Flush(%)	60 vol
Solvent	Hexane:Dichloromethane (1:1, v/v)
Purge	60 sec
Cycle	1

Table 3 indicates the levels of indicator PCBs in 137 samples (cereal, meats, egg, milk and dairy products, fishes and products, and *Fig.* 2 describs distribution pattern of congeners in overall food. The

Table 3. The levels of indicator PCBs in foods

Commodity		No. of Samples	Average (ngg^{-1} fresh weight)												
			28	ΣTriCBs	52	ΣTet-raCBs	101	118	ΣPen-taCBs	153	138	ΣHexaCBs	180	ΣHep-taCBs	Σ_7PCBs
Cereals	Rice (polished)	5	0.03	0.03	0.01	0.01	0.03	0.07	0.10	0.03	0.03	0.06	0.02	0.02	0.23±0.11
	Subtotal (%)	5	0.03 (13.9)	**0.03** (13.9)	0.01 (6.1)	**0.01** (6.1)	0.03 (11.3)	0.07 (31.3)	**0.108** (42.6)	0.03 (13.9)	0.03 (13.0)	**0.06** (27.0)	0.02 (10.4)	**0.02** (10.4)	**0.23** (0.5)
Meats	Beef (lean beef ribs)	5	<0.01	<0.01	<0.01	<0.01	0.02	0.20	0.21	0.17	0.12	0.30	0.11	0.11	0.63±0.16
	Pork (fatback)	5	0.01	0.01	<0.01	<0.01	0.01	0.14	0.15	0.03	0.01	0.04	0.04	0.04	0.25±0.09
	Chicken	5	0.01	0.01	<0.012	<0.01	0.01	0.01	0.02	0.02	<0.01	0.02	<0.01	<0.01	0.06±0.05
	Subtotal(%)	15	0.03 (3.0)	**0.03** (3.0)	0.01 (0.9)	**0.01** (0.9)	0.04 (3.9)	0.35 (37.5)	**0.38** (41.4)	0.22 (24.1)	0.13 (14.2)	**0.36** (38.4)	0.15 (16.4)	**0.15** (16.4)	**0.93** (2.2)
Milk and daily products	Milk	3	<0.01	<0.01	<0.01	<0.01	0.02	0.01	0.03	0.01	<0.01	0.01	<0.01	<0.01	0.04±0.02
	Cheese	9	0.01	0.01	<0.01	<0.01	0.88	0.14	1.00	0.14	0.12	0.26	0.03	0.03	1.30±1.79
	Subtotal(%)	12	0.01 (1.0)	**0.01** (1.0)	<0.01 (0.2)	**<0.01** (0.2)	0.90 (66.9)	0.13 (9.9)	**1.04** (76.9)	0.15 (11.1)	0.12 (9.0)	**0.27** (20.0)	0.03 (1.9)	**0.03** (1.9)	**1.35** (3.2)
Eggs	Egg (York, only)	5	0.03	0.03	0.01	0.01	0.06	0.09	0.14	0.09	0.05	0.14	0.03	0.03	0.35±0.08
	Subtotal (%)	5	0.03 (9.1)	**0.03** (9.1)	0.01 (4.0)	**0.01** (4.0)	0.06 (16.5)	0.09 (24.4)	**0.14** (40.9)	0.09 (24.4)	0.05 (14.2)	**0.14** (38.6)	0.03 (7.4)	**0.03** (7.4)	**0.35** (0.8)

Table 3. Continued.

Commodity		No. of Samples	Average (ngg^{-1} fresh weight)												
			28	ΣTriCBs	52	ΣTet-raCBs	101	118	ΣPen-taCBs	153	138	ΣHexaCBs	180	ΣHep-taCBs	Σ_7PCBs
Fishes and products	Pacific mackerel	10	0.18	0.18	0.45	0.45	0.96	0.79	1.75	1.75	0.84	2.59	0.47	0.47	5.43±2.55
	Hairtail	10	0.35	0.35	0.76	0.76	1.71	1.55	3.26	7.45	1.89	9.34	1.69	1.69	15.41±11.26
	Spanish mackerel	10	0.09	0.09	0.41	0.41	0.94	0.88	1.82	1.61	1.13	2.74	0.37	0.37	5.43±3.03
	Yellow croaker	10	0.40	0.40	0.52	0.52	0.70	0.55	1.25	1.21	0.73	1.94	0.37	0.37	4.48±1.68
	Alaska pollack	10	<0.01	<0.01	0.06	0.06	0.11	0.08	0.20	0.02	0.06	0.08	<0.01	<0.01	0.33±0.27
	Eel	10	0.03	0.03	0.19	0.19	0.41	0.41	0.82	0.93	0.62	1.55	0.24	0.24	2.83±2.56
	Flat fish	5	<0.01	<0.01	0.24	0.24	0.41	0.32	0.73	0.59	0.58	1.17	0.21	0.21	2.34±0.75
	Oyster	10	0.04	0.04	0.07	0.07	0.07	0.07	0.14	0.36	0.03	0.39	0.02	0.02	0.65±0.08
	Crab	10	0.02	0.02	<0.01	<0.01	0.02	0.12	0.14	0.22	0.12	0.34	0.04	0.04	0.55±0.32
	Cuttle fish	5	<0.01	<0.01	<0.01	<0.01	0.12	0.03	0.15	0.07	0.04	0.11	<0.01	<0.01	0.26±0.25
	Dried Anchovy	5	<0.01	<0.01	0.21	0.21	0.40	0.26	0.66	0.57	0.53	1.10	0.14	0.14	2.11±0.46
	Tuna (Canned)	5	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01±0.00
	Subtotal(%)	100	1.11 (2.8)	**1.11** (2.8)	2.90 (7.3)	**2.90** (7.3)	5.84 (14.7)	5.07 (12.7)	**10.92** (27.4)	14.77 (37.1)	6.57 (16.5)	**21.34** (53.6)	3.54 (8.9)	**3.54** (8.9)	**39.81** (93.3)
	Total (%)	137	1.22 (2.9)	**1.22** (2.9)	2.94 (6.9)	**2.94** (6.9)	6.87 (16.1)	5.71 (13.4)	**12.58** (29.5)	15.26 (35.8)	6.90 (16.2)	**22.16** (51.9)	3.77 (8.8)	**3.77** (8.8)	**42.66** (100.0)

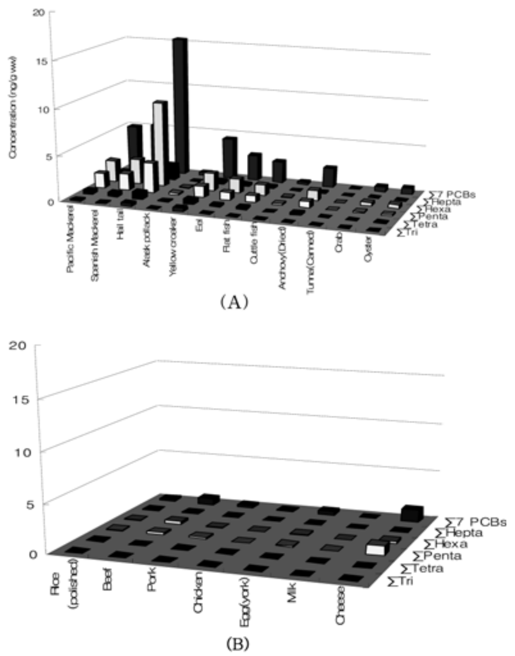

Fig. 2. Patterns for each congeners of indicator PCBs in foods: (A) pacific mackerel(10), spanish mackerel (n=10), hairtail(n=10), alaska pollack(n=10), yellow croaker(n=10), eel(n=10), flat fish(n=5), cuttle fish (n=5), dried anchovy(n=5), canned tuna(n=5), oyster (n=10), crab(n=10); (B) Rice(polished, n=5), beef (n=5), pork(n=5), chicken(n=5), Eggs(n=5) and milk (n=3), cheese(n=9)

indicator PCBs (Σ7(PCBs)) was investigated as 0.2 ng/g for cereal, 0.9 ng/g for meats, 1.4 ng/g for dairy products, 0.4 ng/g for eggs, 39.8 ng/g for fishes and products, respectively. The ratios of each food commodity were 0.5% for cereal, 2.2% for meats, 3.2% for milk and dairy products, 0.8% for eggs, respectively. Fishes and products was the major contaminated food as 93.3%. Hairtail (15.4 ng/g) out of fish was contaminated larger than other commodities in spite of the fat contents was 7.9%. This fish is living up to the depth of water 2,000 m, and the size is maximum 1.2 m.[16]

For the other fish, the level of contamination were 5.4 ng/g for pacific mackerel and spanish mackerel, 4.5 ng/g for yellow croaker, 2.8 ng/g for eel, 2.3 ng/g for flat fish, and 2.1 ng/g for dried anchovy, respectively, and the other fishes and products were investigated lower than these fishes (as <1.00 ng/g).

Oliveria Ribeiro CA *et al*.[17] noted the aquatic environment has revealed an increase in the bioaccumulation levels of PCBs in fish from different regions of the world because these compound is accumulated in aquatic organism through the food chain. The indicator PCBs in food were all detected to be less than the maximum limit (2,000 ng/g) in fish which China[12] established.

3.2. Patterns of indicator PCBs congeners in foods

Table 3 indicates the levels of indicator PCBs and the ratios of each congeners in food examined. The hexa-CBs (51.9%) in food was the most predominant, and the next was penta-CBs (29.5%), hepta-CB (15.8%), tetra-CB (6.9%), and tri-CB (2.9%).

Indicator PCBs in fish from southern Baltic sea during the period from 1997 to 2006, especially, two hexa-CBs, 138 and 153 were the most abundant compounds, and their contribution in a total of seven indicator PCBs reached 60% and penta-CBs was about 10-15%.[18] However, the other food commodities except fish was shown that penta-CBs (40.9-76.9%) was more predominant than hexa-CBs (20.0-38.6%).

For individual congeners of all food, PCB-153 out of hexa-CBs was the most predominant congeners, and it was distributed generally in all food. The next congener was PCB-138, PCB-101, and PCB-118. For cereal, the predominant congeners were PCB-118, 153, 28, 138, 101, and meats was PCB-118, 153, 138, 180, daily products was PCB-101 153, 118, and egg was PCB-153, 118, 101, 138. For fish, PCB-153 out of hexa-CBs was the most predominant congeners, and the next was PCB-138, 101, 118. The ratio for indicator PCBs congeners in all food was contributed as follows 35.8% for PCB-153, 16.2% for PCB-138, 16.1% for PCB-101, 13.4% for PCB-118, 8.8% for PCB-180, 6.9% for PCB-52, and 2.9% for PCB-28.

EFSA assumed that PCB-118 contributes about 15% to the sum of the seven indicator PCBs, the average of PCB-118 in this study was contributed about 13%, and it was similar with EFSA.[6] According to WHO Report,[19] the PCB-153 and 138 are the major congeners found in all animal samples (as here, where PCB-153 was in both liver and muscle). PCB-153 and 138, both with six chlorine atoms, show the highest carry-over into milk and eggs, in the order of 50-60%.[7] In addition, Oliveira Ribeiro *et al.*[17] reported that PCB-28, which may also organs, was found in liver and muscle in the eel (*Anguilla anguilla*), and its bioaccumulation is great in muscle, and so implies a human health risk. PCB-153 in the majority of species is due to its slow rate of biotransformation and elimination. In Czech adult serum, PCB congeners 138, 153, and 180 predominated markedly and accounted for about 97% of the amount of indicator congeners analyzed, and the highest correlations (0.960, p=0.05) were found between PCB-153 and 138.[1] It was predicted that pattern of indicator PCBs may be correlation between food and cumulation in serum on human, even if other sources of contamination effect human health.

In contrast to food, the more volatile lower chlorinated congeners, such as PCB-28, 31, 44, 49, and 52 dominated the PCB composition of air, and many of these congeners are more rapidly metabolized and accumulate to a lesser extent than the congeners more commonly found in food. The PCB composition in soil often resembles more the commercial mixtures

Table 4. Estimated daily intake of indicator PCBs in foods consumed by the Korean populations

Commodity		Food intake ($gday^{-1}$)[1)]		Daily intake of indicator PCBs ($ng\ day^{-1}$)		Estimated daily intake of indicator PCBs ($ngkg\ bw^{-1}\ day$)[2)]	
		Average	95^{th} percentile	Average	95^{th} percentile	Average	95^{th} percentile
Cereals	Rice (polished)	205.7	452.5	47.3	104.1	0.9	1.9
Meats	Beef	17.8	118.8	11.1	74.4	0.2	1.4
	Pork	37.2	183.6	9.2	45.2	0.2	0.8
	Chicken	15.2	82.6	0.9	4.6	<0.1	0.1
Milk and dairy products	Milk	66.5	396.0	2.9	17.0	0.1	0.3
	Cheese	0.6	0.1	0.8	0.1	<0.1	<0.1
Eggs	Egg (york, only)	25.3	100.0	8.9	35.2	0.2	0.6
Fishes and products	Pacific mackerel[3)]	7.5	37.2	40.7	202.0	0.7	3.7
	Hair tail	2.2	0.1	33.9	1.5	0.6	<0.1
	Spanish mackerel	0.6	0.1	3.3	0.5	0.1	<0.1
	Yellow croaker[3)]	4.8	11.5	21.5	51.5	0.4	0.9
	Alaska pollack[3)]	4.6	38.8	1.5	12.8	<0.1	0.2
	Eel	0.6	0.1	1.7	0.3	<0.1	<0.1
	Flat fish	2.1	0.1	4.9	0.2	0.1	<0.1
	Oyster	0.8	0.1	0.5	0.1	<0.1	<0.1
	Crab	2.1	0.1	1.2	0.1	<0.1	<0.1
	Cuttle fish[3)]	5.7	42.0	1.8	10.8	<0.1	0.2
	Dried Anchovy	3.8	13.4	8.0	28.2	0.2	0.5
	Tuna (Canned)	2.0	8.1	<0.1	<0.1	<0.1	<0.1
Total		**405.1**	**1,485.2**	**199.7**	**588.7**	**3.6 (100%)**	**10.7 (100%)**

[1)]Food intakes were proposed by Ministry of Health & Welfare, Korea[15]
[2)]The body weight of overall Korean was 55 kg (average)
[3)]Food intakes were included dried products

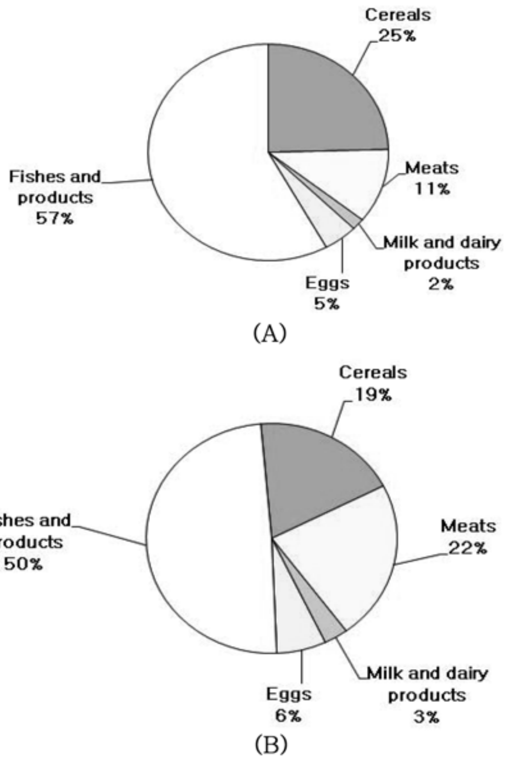

Fig. 3. Average (A) and 95th percentile (B) relative contributions of foods to total 7(PCBs) dietary intake (ng/kgbw/day) estimated for Korean.

deposited or spilled.[6]

3.3. Assessment of dietary exposure for indicator PCBs

For the intake calculations of the present study, the average daily consumption of individual food (g/day) was multiplied with the corresponding concentration levels (ng/g), and estimated daily intake was calculated using average body weight (55 kg bw) of Korean.

Distributions for food intake, daily intake and EDIs of total Σ7(PCBs) in foods including fish are shown displayed in the *Table* 4. Although the contamination levels of fish was higher than the other food, the daily intake and EDIs were expected to be low. The EDIs of total Σ7(PCBs) in overall food were 3.6 ng/kg bw/day (average), and 10.7 ng/kg bw/day (95^{th} percentile). *Fig.* 3 was compared to EDIs (average and 95^{th} percentile) for Korean in food. Fishes and products were taken to represent over 50%, and meats approximately 15%. The EDIs of total Σ6(PCBs) excepted PCB 118 in fisheries and products in general Italian may be taken to represent approximately 39% (average) and 62% (95th percentile) of the overall food, and the next was dairy products and meats.[20] The averaged life-long (70 years) intake was calculated in The Netherland. Median and 95^{th} percentile intake values were found to be 5.6 and 11.9 ng/kg bw/day, respectively. Dietary exposure to PCB was also established in Italy in the mid-1990s. For the sum of the total Σ7(PCBs), an average daily intake of 19 ng/kg bw/day, with 95^{th} percentile of 40 ng/kg bw/day was calculated.[6]

In this study, the dietary exposure to indicator PCBs might slightly overestimate the actual dietary exposure because most analyzes were done on fresh unprocessed foods. Vorspoels S. *et al*.[21] reported that cooking processes have been shown to lead to less of PCBs and other organochlorines in trout, via the less of fat, these reductions varied between 15% and 65% according to their applied cooking process. Consequently, EDIs was estimated more less than the other country, and indicator PCBs in food consumed by Korean could not have adverse effect in risk health.

4. Conclusion

Seven indicator PCBs (IUPAC nos 28, 52, 101, 118, 138, 153, 180 congeners) concentrations were measured in food samples including cereal (polished rice), meats, eggs, milk and dairy products, and fisheries and products as representation for the general Korean populations during 2006-2007, and was analyzed using isotopic dilution method. Fishes had the highest average level as 39.8 ng/g, 1.4 ng/g for milk and dairy products, and 0.9 ng/g for meats. The hairtail out of fishes were contaminated at the level of 15.4 ng/g, 5.4 ng/g for pacific mackerel and spanish mackerel, and 4.5 ng/g for yellow croaker. The ratio for indicator PCBs congeners in overall food was contributed as follows 35.8% for PCB-153, 16.2% for PCB-138, 16.1% for

PCB-101, 13.4% for PCB-118, 8.8% for PCB-180, 6.9% for PCB-52, and 2.9% for PCB-28.The hexa-CBs including PCB-153 and 138 were more predominated, and the next was penta-CBs including PCB-101 and 118 in food. EDIs in average and 95th percentile, fishes and products out of overall food were taken to represent over 50%. However, it was estimated that there was no adverse health effect for Korean.

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