

2016 SCIENTIFIC REPORT



MINISTRY OF FOOD AND DRUG SAFETY

National Institute
of Food and Drug Safety Evaluation

Risk Assessment of Mercury and Methylmercury

Mercury (Hg) is the only metal that exists in the liquid state at room temperature. It is a heavy metal that has been used for a long time together with Pb, and is still used in industry and other areas. Hg in soil consists of 90%–99% inorganic Hg, whereas inorganic Hg in organisms is <1%. Further, methyl Hg is present in a concentration of 1–10% in the soil and 90%–99% in organisms.

The population that is not exposed to Hg in their occupations is mostly exposed to Hg by food intake. Food is a major pathway for Hg exposure, and the long-term intake of fish and shellfish that have accumulated organic mercury (methyl Hg) through the food chain are major sources of exposure. The carcinogenicity, reproductive disorders, and genotoxicity of Hg exposure have not been confirmed, and the nervous system is known to be the most sensitive target organ of Hg.

Most of the nation's Hg exposures are caused by the ingestion of food and drinking water, but the concentration of Hg in domestic drinking water and food products is lower than the control standards. Therefore, health risks due to oral exposure to Hg are estimated to be low. However, some fish (e.g., deep-sea large fish) have high concentrations of methyl Hg and the its standards should be established for these fish. We are trying to reduce food exposure through active publicity regarding the potential health effects of Hg during the excessive Hg intake.

This risk assessment for Hg was conducted in the following four stages in accordance with the Regulations on Risk Assessment Methods and Procedures as well as the Risk Assessment Guide: Hazard identification, hazard characterization, exposure assessment, and risk characterization. The provisional tolerable weekly intake (PTWI) of 3.7 $\mu\text{g}/\text{kg}$ bw/week for

2016 SCIENTIFIC REPORT



MINISTRY OF FOOD AND DRUG SAFETY

National Institute
of Food and Drug Safety Evaluation

Hg and 2.0 $\mu\text{g}/\text{kg}$ bw/week for methyl Hg were applied as the HBGVs.

Target foods were selected from the 2008–2010 (three years) Integrated Database, and this study covered 89% of the total food intakes of Koreans. Food commodities were purchased across Korea between 2012 and 2015. A total of 33,148 cases (agricultural: 11,297, livestock: 9,397, fishery: 6,630, and processed foods: 5,824) for 403 items (agricultural: 136, livestock: 20, fishery: 106, and processed foods: 141) were collected for Hg analysis. Another 866 cases (fishery: 788, processed foods: 78) for 27 items (fishery: 24, processed foods: 3) were collected for methyl Hg analysis.

The analysis of Hg in food was performed using Direct Mercury Analyzer (DMA) and GC with Electron Capture Detector (GC-ECD) for methyl Hg. The absence of Hg and methyl Hg in the analyte indicated that the Hg and methyl Hg concentration was lower than the detection limit of the assay. In risk assessment, half of the detection limit was applied to the undetected results (GEMS/Food- Euro, 1995).

The Hg detection rate in the agricultural products was 93.0%. The Hg concentration was <0.005 mg/kg in most agricultural products, and the average Hg level in the agricultural products was 0.001 ± 0.003 mg/kg.

The Hg detection rate in the livestock products was 94.3%. The Hg concentration was <0.05 mg/kg in most livestock products, and the average Hg level in the livestock products was 0.002 ± 0.003 mg/kg.

The Hg detection rate in the fishery products was 76.2%, and the average Hg level in all fishery products was 0.048 ± 0.14 mg/kg.

The Hg detection rate in processed foods was 93.5%. The Hg concentration in most processed foods was <0.05 mg/kg, and the average Hg level in all processed foods was 0.005 ± 0.015 mg/kg.

2016 SCIENTIFIC REPORT



MINISTRY OF FOOD AND DRUG SAFETY

National Institute
of Food and Drug Safety Evaluation

Table 1. Hg concentration

Categories	Items	Cases	Concentration Levels (mg/kg)							
			No detection cases	Detection rate (%)	Average	Deviation	Min	P50	P95	Max
Agricultural Products	136	11,297	796	93.0	0.001	0.003	<0.000	0.001	0.004	0.072
Livestock products	20	9,397	535	94.3	0.002	0.003	<0.000	0.001	0.006	0.045
Fishery products	106	6,630	1,576	76.2	0.048	0.148	0.002	0.018	0.163	6.339
Processed foods	141	5,824	380	93.5	0.005	0.015	<0.000	0.002	0.022	0.392
Total Foods	403	33,148	3,287	90.1	0.012	0.069	<0.000	0.001	0.051	6.339

* If there is a value below the third decimal point, it is indicated as <0.000.

Table 2. Methyl Hg concentration

Categories	Items	Cases	Concentration Levels (mg/kg)							
			No detection cases	Detection rate (%)	Average	Deviation	Min	P50	P95	Max
Fishery products	25	788	182	76.9	0.143	0.245	0.003	0.037	0.813	0.997
Processed foods	2	78	7	91.0	0.026	0.052	0.003	0.009	0.136	0.318
Total Foods	27	866	189	78.2	0.127	0.232	0.003	0.032	0.755	0.997

* If there is a value below the third decimal point, it is indicated as <0.000.

Risk assessment showed that dietary exposure to Hg remained at safe levels within the health-based guidance values (HBGVs). Average daily exposures in Korean population to Hg was 0.076 $\mu\text{g}/\text{kg}$ bw/day, and the Hg contribution rates were 13% (0.010 $\mu\text{g}/\text{kg}$ bw/day) for

2016 SCIENTIFIC REPORT



MINISTRY OF FOOD AND DRUG SAFETY

National Institute
of Food and Drug Safety Evaluation

agricultural products, 52% (0.039 $\mu\text{g}/\text{kg}$ bw/day) for fishery foods, 1.0% (0.001 $\mu\text{g}/\text{kg}$ bw/day) for livestock products, and 34% (0.026 $\mu\text{g}/\text{kg}$ bw/day) for processed foods.

The products with high average daily exposures to methyl Hg per unit weight due to food intake for people of all ages included general fish, tuna and billfish, and general processed foods (in descending order). Average daily exposures of Koreans to methyl Hg were 0.010 $\mu\text{g}/\text{kg}$ bw/day for general fish, followed by 0.004 $\mu\text{g}/\text{kg}$ bw/day for tuna and billfish, and 0.002 $\mu\text{g}/\text{kg}$ bw/day for general processed foods.

The risk level of Hg exposure was approximately 14.3%. Among the food groups, the risk level of Hg was 1.9% through agricultural products, 0.2% through livestock products, 7.4% through fishery products, and 4.9% through processed foods.

The risk level of methyl Hg exposure was approximately 5.5%. Among the food groups, the risk level of methyl Hg was 4.8% through fishery products and 0.7% through processed foods.

2016 SCIENTIFIC REPORT



MINISTRY OF FOOD AND DRUG SAFETY

National Institute
of Food and Drug Safety Evaluation

Table 3. Hg exposure through food intake

Categories		Exposure Levels (µg/kg bw/day)							
		All ages	≤ 2 years	3 – 6 years	7 – 12 years	13 – 19 years	20 – 64 years	≥ 65 years	
Agricultural products	Cereals	0.009	0.021	0.019	0.014	0.009	0.009	0.011	
	Root and tuber crops	<0.000	0.002	0.001	0.001	<0.000	<0.000	<0.000	
	Beans	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	
	Seeds and nuts	Peanuts or nuts	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000
		Seeds	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000
		Sum	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000
	Fruits	Kernel fruits	0.001	0.004	0.002	0.001	<0.000	0.001	<0.000
		Citrus fruits	<0.000	0.002	0.002	0.001	0.001	<0.000	<0.000
		Stone fruits	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000
		Berries	<0.000	0.001	0.001	<0.000	<0.000	<0.000	<0.000
		Tropical fruits	<0.000	0.001	0.001	<0.000	<0.000	<0.000	<0.000
		Sum	0.001	0.008	0.006	0.002	0.001	0.001	<0.000
	Vegetables	Green head vegetables	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000
		Green vegetables	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	0.001
		Leaf and stem vegetables	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000
		Root vegetables	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000
		Cucurbitaceous fruit vegetables	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000
		Other than cucurbitaceous fruit vegetables	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000
		Sum	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000
	Mushrooms	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	
	Livestock products	Beef	<0.000	0.002	0.001	0.001	<0.000	<0.000	<0.000
Pork		<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	
Other edible meats		<0.000	0	0	0	<0.000	<0.000	<0.000	
Chicken		<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	
Other poultry		<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	
Chicken eggs		0.001	0.003	0.003	0.002	0.001	0.001	<0.000	
Other eggs		<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	
Other animals		<0.000	0	0	0	0.001	<0.000	0	

2016 SCIENTIFIC REPORT



MINISTRY OF FOOD AND DRUG SAFETY

National Institute
of Food and Drug Safety Evaluation

Categories			Exposure Levels ($\mu\text{g}/\text{kg}$ bw/day)							
			All ages	≤ 2 years	3 – 6 years	7 – 12 years	13 – 19 years	20 – 64 years	≥ 65 years	
Fishery products	Fish	Freshwater fish	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	
		Migratory fish	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	
		Marine fish	General fish	0.026	0.026	0.020	0.022	0.011	0.027	0.020
			Deep sea fish	0.002	0	0.001	0.001	0	0.002	0.001
			Tuna and billfish	0.005	0.005	0.001	0.003	0.002	0.006	0.003
			Sum (Marine fish)	0.033	0.031	0.022	0.026	0.013	0.035	0.024
		Sum	0.033	0.031	0.022	0.026	0.013	0.035	0.024	
	Fish eggs	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000		
	Invertebrates	Crustaceans	0.001	<0.000	<0.000	<0.000	<0.000	0.001	<0.000	
		Mollusks	Shellfish	<0.000	<0.000	0.001	<0.000	<0.000	<0.000	<0.000
			Cephalopods	0.004	0.003	0.006	0.005	0.005	0.004	0.001
			Other mollusks	<0.000	<0.000	<0.000	0	0	<0.000	<0.000
			Sum (mollusks)	0.004	0.003	0.007	0.005	0.005	0.004	0.001
		Echinoderms	<0.000	<0.000	0	<0.000	<0.000	<0.000	<0.000	
		Tunicates	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	
		Sum	0.005	0.003	0.007	0.005	0.005	0.005	0.001	
	Seaweeds	0.001	0.004	0.005	0.001	0.001	0.001	0.001		
	Processed foods	Cookies	<0.000	0.003	0.003	0.002	0.001	<0.000	<0.000	
		Bread or rice cakes	0.001	0.002	0.002	0.002	0.001	0.001	0.001	
		Sugar	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	
Fish meat products		0.002	0.004	0.004	0.002	0.002	0.002	<0.000		
Tofu or jellied foods		0.001	0.002	0.002	0.001	0.001	0.001	0.001		
Cooking oils		0.002	0.004	0.004	0.003	0.003	0.002	0.001		
Noodles		0.002	0.002	0.002	0.003	0.002	0.002	0.001		
Teas		0.001	<0.000	<0.000	<0.000	0.001	0.001	<0.000		
Coffee		<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000		
Drinks		<0.000	0.002	0.002	0.001	0.001	<0.000	<0.000		
Special foods		<0.000	<0.000	0	0	0	0	<0.000		
Fermented soy products		<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000		
Seasonings and dressings		<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000		
Kimchi	0.004	0.002	0.003	0.003	0.003	0.004	0.004			

2016 SCIENTIFIC REPORT



MINISTRY OF FOOD AND DRUG SAFETY

National Institute
of Food and Drug Safety Evaluation

Categories		Exposure Levels ($\mu\text{g}/\text{kg}$ bw/day)						
		All ages	≤ 2 years	3 – 6 years	7 – 12 years	13 – 19 years	20 – 64 years	≥ 65 years
	Salted fish products	0.001	<0.000	<0.000	<0.000	<0.000	0.001	0.001
	Salted foods	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000
	Braised foods	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000
	Liquors	0.002	<0.000	<0.000	<0.000	<0.000	0.003	0.001
	Dried fish and shells	0.002	0.001	0.003	0.003	0.003	0.002	<0.000
	Other foods	<0.000	0.001	0.001	0.001	<0.000	<0.000	<0.000
	Nonstandard general processed foods	0.001	0.002	0.003	0.003	0.003	0.001	0.001
	Dairy products	0.007	0.098	0.058	0.025	0.011	0.006	0.004
	Processed meat products	<0.000	<0.000	0.001	<0.000	<0.000	<0.000	<0.000

Table 4. Methyl Hg exposure through food intake

Categories			Exposure Levels ($\mu\text{g}/\text{kg}$ bw/day)							
			All ages	≤ 2 years	3 – 6 years	7 – 12 years	13 – 19 years	20 – 64 years	≥ 65 years	
Fishery products	Fish	Migratory fish	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	
		Marine fish	General fish	0.010	0.012	0.010	0.008	0.003	0.011	0.010
			Deep sea fish	<0.000	0	0.001	0.001	0	<0.000	<0.000
			Tuna and billfish	0.004	0.004	0.001	0.002	0.001	0.005	0.003
			Sum (Marine fish)	0.014	0.016	0.012	0.011	0.004	0.016	0.013
			Sum	0.014	0.016	0.012	0.011	0.004	0.016	0.013
	Fish eggs	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000		
Processed foods		Salted fish products	<0.000	<0.000	<0.000	<0.000	<0.000	<0.000		
		Nonstandard general processed foods	0.002	0.003	0.004	0.004	0.004	0.002	0.001	

The current exposure levels of Hg and methyl Hg through foods have been estimated to be safe, but the contribution rates to exposure from some fishery products such as deep-sea fish are still high. Thus, continuous research on fishery products is required. In this risk

2016 SCIENTIFIC REPORT



MINISTRY OF FOOD AND DRUG SAFETY

National Institute
of Food and Drug Safety Evaluation

assessment, the exposure levels of Hg and methyl Hg through foods (89% of daily food intake) were 14.3% and 5.5%, respectively, compared to the safety standard for human exposure, thereby indicating that these are relatively safe for consumption.

However, some large carnivorous fish (e.g., shark, swordfish, and tuna) have higher levels of accumulated Hg than other fish and clams. In the case of these fish, we are making efforts to reduce Hg exposure through continuous publicity regarding the intake and health effects that could occur if the Hg exposure standard is exceeded.

This report is based on published research results. Therefore, the data in this report will be reassessed when new information has been identified or sufficient monitoring data are available.

Key words: Mercury, Methylmercury, Analysis, Food, Source of exposure, Exposure Level, Risk Assessment, Toxicity, Provisional Tolerable Weekly Intake