

INVESTIGATION OF DAILY INTAKE OF DIOXINS FROM RICE IN KOREA

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Introduction

Dioxins including dioxin-like compounds are known as by-products of various industrial processes with high toxicity and bioaccumulation. They include polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs).¹ And World Health Organization (WHO) set a tolerable daily intake (TDI) for dioxins at 4 pg-TEQ_{WHO}/kg body weight (b.w.)/day as well as Korean Food and Drug Administration (KFDA).² Thus, number of researchers investigated the contamination of PCDD/Fs and DL-PCBs in livestock products, dairy products, marine products, and farm products.³⁻⁸

The monitoring research for Korean foods were performed by Oh et al.⁹ However, they only selected 14 samples for dioxins monitoring in rice, and there was not enough to estimate daily intake of dioxins from rice. As part of these ongoing studies on dioxins contamination in Korean rice, this study was to determine the levels of 17 PCDD/Fs, 12 DL-PCBs by HRGC/HRMS in Korean rice that were produced in whole country.

Materials and methods

Samples

In this research, total number of samples was 36 from 8 provinces and all sample were used as white rice. It was ground and stored in freezer before analysis.

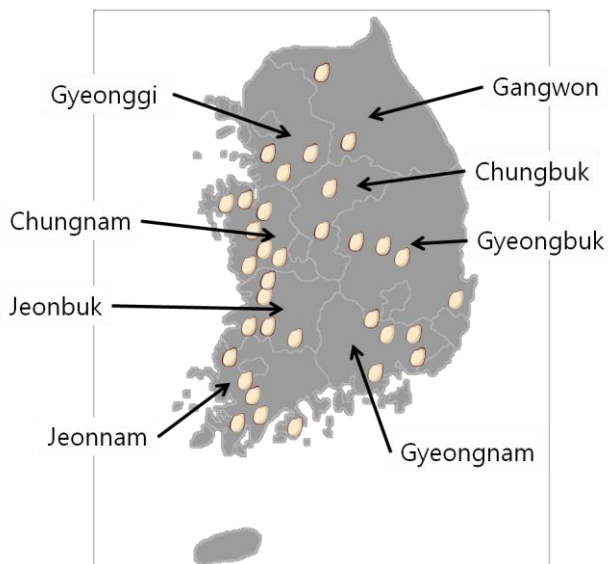


Figure 1. Sampling locations as major production area from 8 provinces in Korea

Analysis

All the analytical samples for dioxins were prepared according to the method of Zhang *et al.*¹⁰ with several modifications. Glass fiber thimbles and the Soxhlet system were pre-extracted with hexane/dichloromethane (1/1) for at least 16 h. Briefly, 50 g of samples were extracted by the Soxhlet system and filtered, and then all samples were spiked with a mixture of ¹³C₁₂-labelled 29 PCDD/Fs and DL-PCBs congeners (Wellington Laboratories, Ontario, Canada). The extract was transferred to separation funnel, after which concentrated sulfuric acid was added to the organic phase and mixed for the elimination of pigment. Then the organic phase was washed with distilled water and concentrated under reduced pressure.

Clean-up procedure was performed with the PowerPrep automated system (Fluid Management System Inc., Waltham, Massachusetts). The system was equipped with three types of columns with silica, alumina and activated carbon. After washing with hexane, mono- and di-ortho PCBs were eluted with 2% and 50% dichloromethane in hexane respectively (Fraction 1). PCDD/Fs and non-ortho PCBs were eluted with toluene (Fraction 2). Then as injection standard solution, ¹³C₁₂-labeled PCBs IUPAC 70, 111 and 138 were spiked to Fraction 1. For Fraction 2, 1,2,3,4,6-PentaCDF and 1,2,3,4,6,8,9-HeptaCDF with above labeled PCB congeners were added.

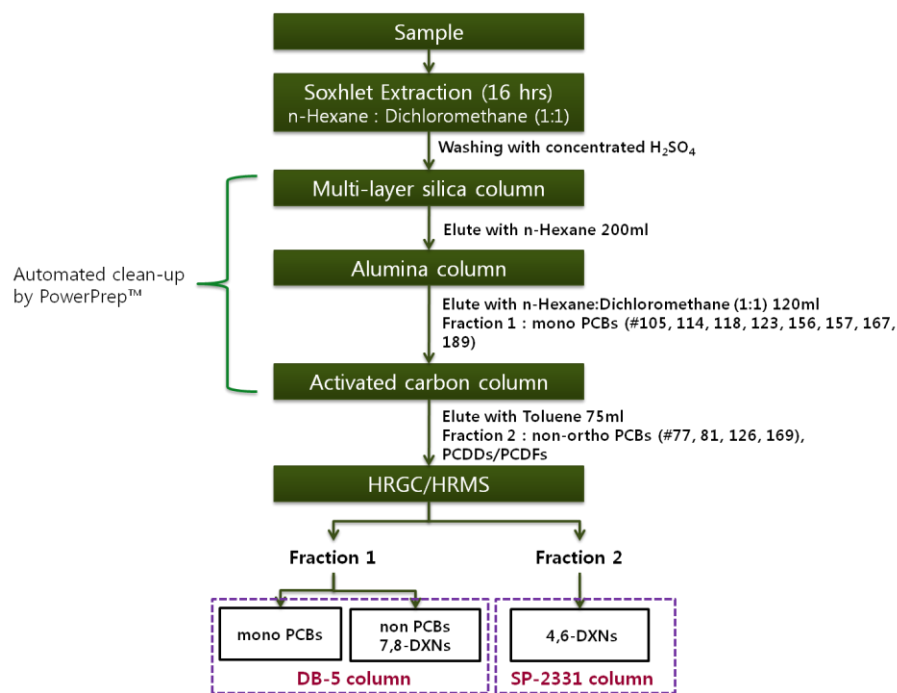


Figure 2. Schematic diagram of pretreatment procedure for the analysis of PCDD/Fs in rice

Quantification and identification of PCDD/Fs and DL-PCBs were performed with HRGC-HRMS system. The analysis was conducted with DB-5MS (60 m × 0.25 mm × 0.25 μm) and SP-2331 (60 m × 0.25 mm × 0.25 μm). The HRGC-HRMS program was operated in electron impact ionization (EI) mode at a resolution of more than 10,000 using multiple ion detection (MID). We used the non-detects as equal to zero. TEQ levels of dioxins were expressed in pg-TEQ_{WHO}/gram using the appropriate WHO toxic equivalent factor (WHO-TEF).

Results and discussion

The contamination levels of PCDD/Fs were ranged from no detection level to 1.3213 pg/g fresh weight (f.w.). The half provinces located east and north part were showed higher level of PCDFs than PCDDs. And all residual

DL-PCBs in rice were 2.1305 ~ 4.9830 pg/g f.w., and this is higher sum level of PCDDs/Fs. Thus their TEQ values ranged 0.0009 ~ 0.0220 pg-TEQ_{WHO}/g f.w., and their average value was 0.0072 pg-TEQ_{WHO}/g f.w.

Table 1 The average TEQ concentration of PCDDs, PCDFs and DL-PCBs in Korean rice, pg-TEQ_{WHO}/g f.w.

Province	PCDDs	PCDFs	DL-PCBs	Total TEQ
A	0.0030	0.0190	0.0000	0.0220
B	0.0008	0.0013	0.0090	0.0111
C	0.0000	0.0000	0.0024	0.0024
D	0.0011	0.0001	0.0018	0.0030
E	0.0001	0.0004	0.0100	0.0105
F	0.0006	0.0001	0.0002	0.0009
G	0.0003	0.0010	0.0019	0.0032
H	0.0000	0.0044	0.0000	0.0044
Average	0.0005	0.0020	0.0031	0.0056

Estimated daily intake (EDI) for population were calculated by multiplying the measured TEQ concentration based on the food consumption data of the local residents that were investigated for Korean, and the results were divided by 60 to obtain average daily exposure per kg of body weight. The total daily intake of dioxins from rice was estimated 1.0287 pg-TEQ_{WHO}/day/person, and the estimated intake of dioxins was 0.0171 pg-TEQ_{WHO}/kg b.w./day from Korean rice, and the rice contributed 0.43 % of Korean TDI.

Table 2 Estimated daily intake (EDI) to the dioxins of Korean rice

Province	Daily Intake(g)*	Daily intake of dioxins (pg-TEQ _{WHO} /day/person)	Estimated intake of dioxins (pg-TEQ _{WHO} /kg b.w./day)
A		4.0414	0.0735
B		2.0391	0.0371
C		0.4409	0.0080
D		0.5511	0.0100
E	183.1	1.9289	0.0350
F		0.1653	0.0031
G		0.5878	0.0107
H		0.8083	0.0147
Average		1.0287	0.0187

* Daily intake values were referenced from Korea National Health and Nutrition Examination Survey in 2007 [Korean CDC, 2008]

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