

Concentrations of PCDDs, PCDFs and Coplanar PCBs in Cigarettes From Various Countries

Matsueda, T., Kurokawa, Y., Nakamura, M., Takada, S. and Fukamachi, K.
Fukuoka Institute of Health and Environmental Sciences, 39 Mukaizano, Dazaifu
Fukuoka, 818-01 Japan.

Introduction

Polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and coplanar polychlorinated biphenyls (Co-PCBs) have been detected in virtually all media¹, including air, soil, vegetation, fish, human tissue, human breast milk², and marine mammalian wildlife. These organochlorinated compounds cause toxic symptoms, including a wasting syndrome, hepatic damage, reproductive toxicity, and immunotoxicity. Even though there is a great deal of evidence pointing to the extreme toxic potential of these compounds, very limited information on their concentrations in the cigarette and/or cigarette smoke are available^{3,4}. We have already demonstrated that practical amounts of PCDDs and PCDFs in cigarette smoke derived from cigarette leaves⁵. The objectives of this study was to estimate the levels of PCDDs, PCDFs and Co-PCBs in cigarette leaf from various countries.

Experimental

Twenty brands of commercially available cigarettes were collected from Japan, United States, Taiwan, China, United Kingdom, Germany and Denmark in April to September, 1992. The cigarette samples were separated from the part of rapping paper and leaf then extracted with acetone, acetone/hexane and hexane using POLYTORON™ homogenizer. The extracts were fortified with ten kinds of ¹³C-labeled PCDDs/PCDFs and three kinds of ¹³C-labeled Co-PCBs as internal quantitation standards. The extract was purified on a AgNO₃-silica gel and charcoal column. The PCDDs/PCDFs and Co-PCBs were analyzed by HRGC/HRMS technique using a Finnigan MAT-90 mass spectrometer (Finnigan MAT, Germany) directly interfaced with a Varian Model 3400 gas chromatograph. Co-PCBs, HpCDDs/HpCDFs and OCDD/OCDF were measured with 50 % methyl phenyl silicon, OV-17 (0.25mmX25m, film thickness, 0.1mm) and for the analysis of other PCDDs/PCDFs, SP-2331 capillary column (0.32mmX60m; film thickness, 0.25mm) was used. The mass resolution (5 % valley) was 7000 to 8000. Two ions of molecular cluster were recorded.

Results and discussion

Table 1 shows the concentrations of PCDDs/PCDFs and Co-PCBs detected in the cigarette samples obtained from the seven countries. The 2,3,7,8-TCDD toxic equivalents (TEQs) of PCDDs and PCDFs were calculated using I-TEF and those of the Co-PCBs were calculated using the data reported by Safe⁶. The total concentrations of PCDDs/PCDFs and Co-PCBs in cigarette leaves ranged from 52.3 to 913.6, 56.3 to 599.5 and 15.3 to 150.8 pg/packet, respectively. As shown in Table 1, the PCDDs/PCDFs

SOU/FRM

Table 1 Concentrations of PCDDs, PCDFs and Co-PCBs in cigarettes from various countries (pg/packet)

Congener	USA* (n=7)	Japan* (n=6)	UK* (n=3)	Taiwan (n=1)	China (n=1)	Denmark (n=1)	Germany (n=1)
2,3,7,8-TCDD	1.2	0.5	1.7	1.0	0.0	0.5	1.1
Other TCDDs	45.9	295.8	83.4	328.0	9.7	16.5	48.4
2,3,7,8-PnCDD	1.6	1.4	3.1	3.3	1.1	0.8	3.3
Other PnCDDs	26.0	32.2	59.8	147.2	4.1	9.0	37.5
2,3,7,8-HxCDDs	6.9	4.8	6.1	12.2	1.1	6.2	5.7
Other HxCDDs	33.7	24.4	43.1	87.2	4.3	20.5	34.9
2,3,7,8-HpCDDs	52.7	17.8	23.9	26.4	2.2	53.3	32.7
Other HpCDDs	56.0	22.2	23.8	35.6	1.6	39.8	27.5
OCDD	589.3	244.0	189.5	272.7	28.2	354.3	288.6
2,3,7,8-TCDF	18.2	4.8	15.6	11.0	1.2	2.2	7.9
Other TCDFs	165.6	97.3	333.3	361.1	34.2	95.6	225.5
2,3,7,8-PnCDFs	8.7	5.3	21.2	16.0	1.5	4.3	14.4
Other PnCDFs	49.0	40.6	113.3	133.1	9.7	31.2	83.1
2,3,7,8-HxCDFs	8.1	8.1	17.0	12.9	2.2	4.3	13.2
Other HxCDFs	21.0	18.3	34.3	32.9	5.6	13.8	27.6
2,3,7,8-HpCDFs	17.6	11.1	13.6	13.2	1.5	7.0	12.9
Other HpCDFs	9.7	5.5	5.4	5.3	0.2	4.1	8.3
OCDF	24.6	10.5	8.3	13.9	0.5	10.5	13.9
3,3',4,4'-TCB	105.7	70.2	53.0	133.9	12.6	21.7	39.3
3,3',4,4',5-PnCB	6.2	7.8	6.1	14.5	2.4	2.2	7.3
3,3',4,4',5,5'-HxCB	0.9	0.9	0.9	2.4	0.4	0.5	1.6
Total PCDDs	813.3	643.2	434.5	913.6	52.3	500.9	479.7
Total PCDFs	322.6	201.4	561.9	599.5	56.3	173.1	406.8
Total PCDDs/PCDFs	1135.9	844.7	996.4	1513.1	108.6	674.1	886.5
Total Co-PCBs	112.8	78.9	60.0	150.8	15.3	24.4	48.2
Total PCDDs TEQ	3.8	2.1	4.3	4.4	0.7	2.5	3.9
Total PCDFs TEQ	4.8	2.5	8.3	4.9	0.7	1.3	5.2
Total PCDDs/PCDFs TEQ	8.6	4.6	12.6	9.3	1.4	3.8	9.1
Total Co-PCBs TEQ	1.7	1.5	1.2	2.9	0.4	0.5	1.2
Total PCDDs/PCDFs & PCB TEQ	10.3	6.1	13.8	12.2	1.8	4.2	10.3

*: Values obtained from these countries were expressed as mean concentrations

levels in Chinese cigarette were extremely low comparing with other countries' cigarettes. There are remarkable differences among TCDD levels of samples obtained from Japan and Taiwan and those from U.S., U.K., Denmark and Germany which ranged from 296.3 to 329.0 pg/packet and 17.0 to 85.1 pg/packet, respectively. The OCDD levels of cigarettes made in U.S. and Denmark are somewhat higher than those of other countries. The levels of PCDFs were almost the same among the cigarettes tested except for Chinese cigarette. Figure 1 shows the homologue patterns of PCDDs/PCDFs. There was a great similarity in the homologue pattern of PCDFs among the cigarettes tested. However, Japanese and Taiwanese cigarettes show PCDD homologue patterns different from other countries' cigarettes, i.e., TCDD was abundantly present in cigarettes made in Japan and Taiwan. On the other hand, OCDD was the most abundant in cigarettes made in other countries. This indicates the possibility that there is a difference in contamination sources among these two groups of countries. As shown in Figure 2, the homologue patterns of Co-PCBs in the cigarette leaves are similar to each other, but there is some variation in the level of Co-PCBs. Figure 3 shows the TEQ levels in cigarettes tested. The total TEQ levels ranged from 1.8 (China) to 13.8 (U.K.)pg/ packet. In our previous study on the origin of PCDDs/PCDFs in cigarette smoke, almost all of them were considered to be derived from cigarette leaf⁶⁾, and PCDDs/PCDFs in cigarette leaf

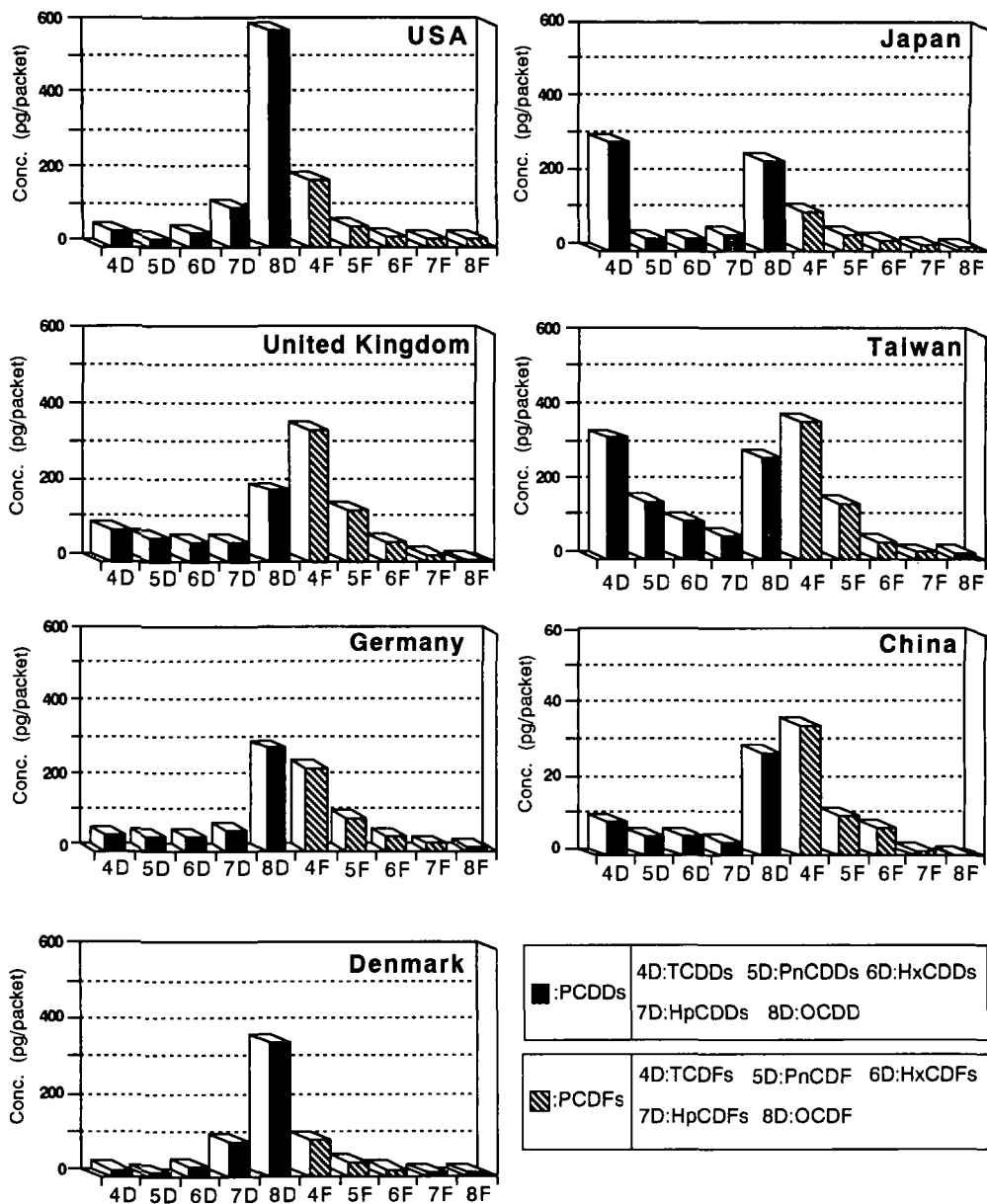


Figure 1 Homologue patterns of PCDDs, PCDFs in cigarettes from various countries

contribute nearly 35 % to the main-stream smoke. On the basis of these results, intake of TEQ values via cigarette smoking for 1 packet was estimated to be from 0.6 to 4.8 pg TEQ.

SOU/FRM

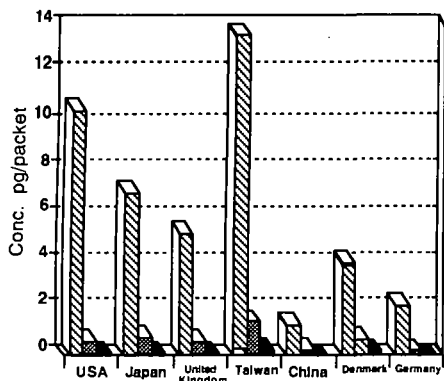


Figure 2 Homologue patterns of Co-PCBs in cigarettes from various countries

▨ :TCB ▩ :PnCB ■ :HxCB

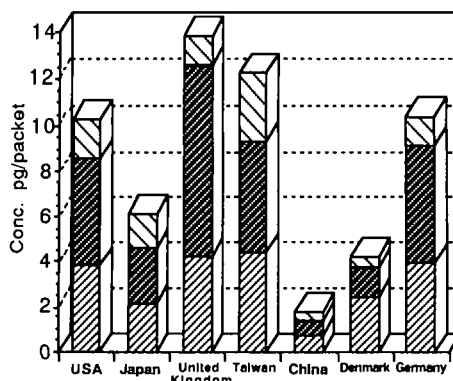


Figure 3 TEQ levels in cigarette samples from various countries

▨ :PCDD ▩ :PCDF □ :Co-PCB

Conclusions

This study presents data on the PCDDs/PCDFs and Co-PCBs levels in cigarette leaf samples obtained from seven countries. The concentrations of TEQs in cigarette leaf ranged from 1.8 to 13.8 pgTEQ/packet. Some differences in the homologue patterns were observed among cigarettes tested. The presence of PCDDs/PCDFs and Co-PCBs in cigarette leaf samples can be attributed to a variety of sources including manufacturing processes like drying after harvesting and/or atmospheric deposition from air in a cultivation of tobacco plants.

References

- 1) Rappe C. (1993): Environmental Concentrations and Ecotoxicological Effects of PCDDs, PCDFs and Related Compounds. *Organohalogen compounds*. **12**, 163-170
- 2) Matsueda T., T. Iida, H. Hirakawa, K. Fukamachi, H. Tokiwa, and Nagayama, J. (1993): Toxic Evaluation of PCDDs, PCDFs and Coplanar PCBs in Breast-fed Babies of Yusho and Healthy Mothers. *Chemosphere*. **127**, 187-194
- 3) Muto H. and Y. Takizawa (1989) : Dioxins in Cigarette Smoke. *Arch. Environ. Health*. **44**, 171-174
- 4) Matsueda T., Y. Kurokawa, Y. Ohsaki, H. Hirakawa, and T. Iida (1991): Effect of Cigarette Smoking on the Concentration of Polychlorinated Dibenzop-dioxins and Polychlorinated Dibenzofurans in Indoor Air. *J. Environ. Chem.* **2**, 791-799
- 5) Matsueda T., H. Hirakawa, T. Iida, Y. Kurokawa, and Y. Ohsaki (1991) : Concentration of Polychlorinated Dibenzop-dioxins and Polychlorinated Dibenzofurans in Cigarette Smoke. *Annual meeting of Japan Society of Air Pollution .Proceedings*. p.475
- 6) Safe S. (1990) : Polychlorinated Biphenyls(PCBs), Dibenzop-dioxins(PCDDs), Dibenzofurans (PCDFs), and Related Compounds: Environmental and Mechanistic Considerations which Support the Development of Toxic Equivalency Factors (TEFs). *Critical Reviews in Toxicology*. **21**, 51-88