POLYCHLORINATED NAPHTHALENES (PCNS) IN THE RICE OIL POISONINGS

John J. Ryan[A] and Yoshito Masuda[B]
[A]Food Research Division, Health Protection Branch, Health Canada, Ottawa K1A 0L2, CANADA and [B]Daiichi College Pharmaceutical Sciences, Fukuoka 815, JAPAN

The two rice oil incidents in Japan in 1968 (yusho) and in Taiwan in 1979 (yu-cheng) have traditionally been referred to as PCB poisonings since the heat exchanger media which leaked into the food grade oil consisted of commercial PCBs. Due to the elevated temperatures combined with ageing, the heat exchange media in both cases also contained[1,2] a number of other compounds. These include the dimeric polychlorinated quaterphenyls (PCQs) in similar amounts as the PCBs, sulfur derivatives of the PCBs, small concentrations of the biologically potent polychlorinated dibenzofurans (PCDFs), and even smaller quantities of the polychlorinated dibenzo-*p*-dioxins (PCDDs). Subsequent investigation[3] of the rice oils and exposed individuals showed that the most toxic components were the PCDFs and not the PCBs even though this factor is not always acknowledged. As a result, early attempts to estimate exposure of the rice oil victims focused on blood or tissue levels of the PCBs and, less so, of the toxicologically benign PCQs. In recent years, most exposure estimation has centred on the PCDFs[4] particularly the 2,3,4,7,8-pentachlorodibenzofuran (PnCDF) and 1,2,3,4,7,8-hexachlorodibenzofuran (HxCDF) congeners due to their relatively high concentrations and elevated toxicity. As the yusho and yu-cheng are two human exposures that resulted in severe health effects, it is important to identify all compounds in the exposure mixture. The adverse effects may be a combination of interaction among several ingredients and not the most toxic PCDFs in isolation.

Polychlorinated naphthalenes (PCNs) are chlorinated aromatic hydrocarbons which were once produced as commercial products[5] although not to the same extent as the PCBs. For example, one of the well known PCNs used as a cable insulator, Halowax 1014, contains about 62 % chlorine divided among the tetra-, penta, and hexa- homologues in the approximate ratios of 1:2:2. PCNs which comprise up to 75 congeners are similar in both chemical structure and biological activity as the PCBs, PCDFs, and PCDDs. In fact exposure to certain PCNs in either animals or man produces severe skin changes[6,7], the hallmark of so-called dioxin-like activity. Although PCNs have not been thoroughly studied, they are known to appear as

minor components of PCBs[8], have been found in diverse biota[9] and even at low 10^{-9} concentrations in human adipose tissue from general populations[10]. A limited number of pure standards of the PCNs have become available recently[11]. We have used these to investigate the role of PCNs in the yusho and yu-cheng episodes using rice oil and human blood samples.

EXPERIMENTAL

Standards A crystalline mixture containing approximate equal amounts of the congeners 1,2,3,4,6,7- and 1,2,3,5,6,7-hexachloronaphthalene (HxCN) was a gift from D. Williams, Environmental Health Directorate, Health Protection Branch, Health Canada. These two congeners cannot be separated by gas chromatography but are separated by liquid chromatography. Mixtures of commercial PCNs, the Halowax series, were obtained from commercial sources.

Sampling Human blood samples from a previous study[4] had already been analyzed for PCDFs, PCDDs, and PCBs (di-ortho, mono-ortho, and planar). Extracts from these purified whole blood samples were used for further analysis. Two milk samples taken in 1988 and 1993 from yusho individuals were also available for study. Rice oil samples were obtained from the yusho incident in 1968 of manufacturing date 5th February and from the yu-cheng incident in 1979 from Taichung.

Analysis The method used to analyze the blood samples has been described[4,12]. To test the characteristics of the above method for PCNs, two test materials were assayed. These are the two accumulating early co-eluting hexacongeners (1,2,3,4,6,7- and 1,2,3,5,6,7-) with lateral 2,3,7,8-substitution and the most chlorogenic active mixture, Halowax 1014. The former pure standard was found to track through the method as other dioxin-like compounds i.e. when spiked into a sample, it appeared in the same final extract with the PCDDs/PCDFs/pPCBs and no measurable amounts could be detected in other fractions. For the Halowax mixture, 4 of 6 penta congeners and 4 of 6 hexa congeners including congeners with the same retention time as the test hexa standard were found in the dioxin fraction.

For measurement of the PCNs, the same GC-MS conditions as previously described[4,12] along with appropriate ions for the tetra-, penta-, and hexa- congeners were employed. As no ^{13}C-PCN was available, it was assumed that the recovery of the PCNs through the method was similar to that of the internal standard ^{13}C-2,3,7,8-TCDD. A series of calibration standards with varying amounts of HxCNs and fixed amount of ^{13}C-2,3,7,8-TCDD was used to establish response, linearity, and relative response factors for HxCN/TCDD.

RESULTS

PCNs could not be detected in most of the biological samples originating from yusho. These include all blood samples obtained between 1982 and 1990. In the two yusho milk samples levels about 100 ppt on a fat basis were found which do not appear to be much different from contemporary milk samples. These results probably reflect the long time between exposure and sample collection in the yusho incident and the relatively small sample size in the case of the blood samples.

PCNs could be readily found in the series of blood samples from the 3 yu-cheng individuals and these results are summarized.

Table: 1,2,3,4,6,7/1,2,3,5,6,7-HxCN in blood samples from three yu-cheng individuals; values in μg/kg whole blood lipid

Name	BS	RK	SS
Days after first sampling			
0	8.59	12.8	14.1
171	30.4	26.9	14.0
425	10.5	11.2	--
1049	1.99	4.95	1.64
2025	1.47	--	1.41
3502	--	1.15	--
Half Life; yr	1.5	2.4	1.5

The profiles (number and relative amounts of the individual congeners) of these blood samples is somewhat unique in that there is only one hexa- congener, the early eluting 1,2,3,4,6,7/1,2,3,5,6,7-HxCN, and little or no tetra- or penta- congeners. As such they are similar to the profile we found in a limited number of fish from the Great Lakes and the commercial PCB, Arochlor 1254. For instance, Aroclor 1254 contained approximately a ΣHxCN of 15 ppm with the early eluting hexa- isomer at 3 ppm and ΣPnCN at about 0.4 ppm. Whether the presence of the highly accumulating hexa congeners represents a toxic risk is not certain.

CONCLUSION

PCNs particularly the HxCN and less so PnCN congeners have been found at high 10^{-9} concentrations in early yu-cheng samples with a half-life similar to PCDFs[4]. In addition measurable levels can be found in other biological samples. The toxicological significance of

these findings is uncertain given the sparse data available on the biological activity of the PCNs. Further analytical results are being gathered on additional biological samples of both general and rice oil origin to augment this data base.

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