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Risk assessment study of dioxins in sanitary napkins produced in Japan

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ABSTRACT

A risk assessment study of dioxins in sanitary napkins produced in Japan was performed. The daily estimated exposure volume to dioxins was compared with the tolerable daily intake (TDI). The concentrations of dioxins such as polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and dioxin-like polychlorinated biphenyls (DL-PCBs) in seven sanitary napkins were measured using gas chromatography and mass spectroscopy analytical methods. Among the seven napkins, a range of 0.0044–0.076 pg TEQ/g dioxins was measured. Daily estimated exposure volume from sanitary napkins was calculated as follows: (dioxin volumes in a sanitary napkin (0.0044–0.076 pg TEQ/g) × pulp weight in a sanitary napkin (11.2 g) × used napkin numbers/d (7.5) × the number of days/month that women use sanitary napkins (7) × skin absorption rate (0.03) × used years (40))/(average body weight of women (50 kg) × the number of days in the month (30) × life years (86)). Daily exposure volumes were estimated to be 0.000024–0.00042 pg TEQ/kg/d. For hazard assessment, we used 0.7 pg TEQ/kg/d which was the lowest level of TDI among TDI values reported by international agencies. When the daily exposure volume was compared with the TDI, the former was approximately 1666–29,166 times less than the latter. This fact indicated that the risk of exposure to dioxins from sanitary napkins produced in Japan was negligible.

1. Introduction

Dioxins are very toxic environmental pollutants. There is great public concern about the impact of dioxins on human health, and various toxic effects have been reported in humans, primates, and other experimental animals (Bellelis et al., 2011; Cummings et al., 1999; Gies et al., 2007; Rier et al., 1993; U.S. EPA, 2000, 2009, 2012; Van den Berg et al., 1998, 2006; Yang et al., 2000).

Humans are exposed to dioxins mainly through food (Government of Japan, 2012), and other sources of dioxins in the food chain are the products of combustion mechanisms used in municipal, hazardous, and medical waste incinerators. Dioxins are also produced in a variety of industrial processes, such as the bleaching of wood pulps with elemental chlorine. Consequently, so-called chlorine-bleached paper products are often the subject of speculation regarding the potential risk of dioxins from consumer product use (DeVito and Schecter, 2002). There are several reports on the presence of dioxins in fluff pulp used as the absorbent core in sanitary products (DeVito and Schecter, 2002; Schecter et al., 1998; Wilberg et al., 1989), and risk assessment has already been performed. It was reported that there is little risk of exposure to dioxins in tampons (DeVito and Schecter, 2002). In Japan, over 90% of menstruating women use sanitary napkins, which include pulp (Yokose, 2009). However, there is little information on the presence of dioxins in sanitary napkins and the safety of using them. On the other hand, women in Japan worry about whether the use of sanitary napkins increases the risk of endometriosis based on the experimental toxicity study of endometriosis in rhesus monkeys treated with 2,3,7,8-tetrachlorodibenzo-p-dioxin (Rier et al., 1993). Therefore, we performed this risk assessment study by measuring the levels of dioxins in fluff pulp used in sanitary napkins and by comparing the daily exposure volume of dioxins from sanitary napkins and the tolerable daily intake (TDI) from toxicity data.

2. Materials and methods

2.1. Exposure assessment to dioxins from sanitary napkins

Seven samples of fluff pulp used as the absorbent core in sanitary napkins were received from Unicharm Corporation (Minato-ku, Tokyo, Japan). These samples were products supplied from different sources or from the same source under different

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product names. This brand comprises 45% of the sanitary napkins sold in Japan, 40% in Indonesia and 40% in Taiwan, and 50% in Thailand, so it may be said that it is a representative product in Asia (personal information by Unicharm Corporation).

We used the following equation to estimate the daily exposure volume of dioxins from using sanitary napkins for the screening level analysis:

$$\text{Daily exposure volume} = \frac{C \times T \times N \times D \times A \times Y}{\text{bw} \times 30 \times L}$$

where C is the concentration of dioxins from the sanitary napkin expressed as dioxin equivalents (pg TEQ/g), T is the weight of the pulp in a sanitary napkin, N is the number of sanitary napkins used per day, D is the number of days per month that women use sanitary napkins, A is the skin absorption rate of dioxins, Y is the number of years in the life of the average woman, bw is the average woman's weight, 30 is the number of days in a month, and L is the number of years in the life of the average woman. This method principally followed screening-level analysis method of dioxins in tampons and diapers performed by DeVito and Schecter (2002).

The concentrations of polychlorinated dibenzo-p-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and dioxin-like polychlorinated biphenyls (DL-PCBs) in fluff pulp samples of sanitary napkins were determined as follows.

About 50 g of pulp of each sanitary napkin was weighed accurately, and subjected to extraction by a soxhlet extractor with toluene for 16 h. The crude extract was concentrated and placed in hexane. The obtained solution was subjected to different column chromatographies such as multilayered silica gel chromatography, active carbon chromatography and alumina chromatography. The sample solution was analyzed with a gas chromatograph–high resolution mass spectrometer (GC–HRMS).

The concentrations of PCDDs (TeCDDs, PeCDDs, HxCDDs, HpCDDs, OCDD), PCDFs (TCDFs, PeCDFs, HxCDFs, HpCDFs, OCDF) and DL-PCBs (non-ortho, mono-ortho) were determined. We followed a manual for the determination of dioxins in air, soil and bottom sediment to assure the reliability of the measured data (JMOE, 2001, 2008a,b). The Toxic Equivalency Quantity (TEQ), using the World Health Organization's toxic equivalency factors (TEF) (Van den Berg et al., 2006), was calculated for each sample. Dioxin levels in some products were lower than the limit of detection (LOD). In these cases, we calculated TEQ as LOD/2 according to international risk assessment methods (EFSA, 2010).

2.2. Hazard assessment

The TDI of dioxins has been published by various assessment agencies such as the WHO European Centre for Environment and Health International Programme on Chemical Safety (WHO, 1998), United Kingdom Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (U.K. COT, 2001), Japan Ministry of Health, Labour and Welfare/Japan Ministry of the Environment (JMHLW/JMOE, 1999), EC Scientific Committee on Food (EC SCF, 2001), the Joint FAO–WHO Expert Committee on Food Additives (JECFA, 2001), and United States Environmental Protection Agency (U.S. EPA, 2012). In this study, we selected the lowest value of TDI of dioxins published by these agencies.

2.3. Risk characterization

We performed risk assessment by comparing the daily exposure volume and TDI.

3. Results

3.1. Assessment of exposure to dioxins from sanitary napkins

The concentration of dioxins in seven samples of fluff pulp used as the absorbent core in sanitary napkins and their equivalent volumes are shown in Tables 1 and 2, respectively. Among these samples, the lowest concentration of dioxins was 0.0044 pg TEQ/g (Sample No. 3, 4, 5) and the highest concentration was 0.076 pg TEQ/g (Sample No. 2). The total dioxins concentrations among the seven samples (0.0044–0.076 pg TEQ/g) were correlated to the percentage of the DL-PCBs concentrations out of the total dioxins concentrations.

The daily exposure volume of dioxins for the screening-level analysis was estimated by the method described in the "Materials and methods" section (Table 3). The pulp weight (T) was 11.2 g/napkin, which was obtained from Unicharm Corporation. We set the number of napkins used/d (N) as 7.5. The number of days used

Table 1
Real concentrations of dioxins in seven samples of fluff pulp used as the core absorbent in sanitary napkins.

Dioxin compounds		LOD	Concentration (pg/g)						
			No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
PCDDs (polychlorinated dibenzo-p-dioxins)	TeCDDs	0.002	ND	ND	ND	0.047	0.012	0.042	ND
	PeCDDs	0.002	ND	ND	ND	ND	ND	ND	ND
	HxCDDs	0.002–0.005	ND	ND	ND	ND	ND	ND	ND
	HpCDDs	0.005	ND	ND	ND	ND	ND	ND	ND
	OCDD	0.007	ND	0.010	0.021	ND	ND	0.013	ND
PCDFs (polychlorinated dibenzofurans)	TeCDFs	0.002	ND	ND	ND	0.015	ND	ND	ND
	PeCDFs	0.002	ND	ND	ND	ND	ND	0.068	ND
	HxCDFs	0.002–0.007	ND	ND	ND	ND	ND	ND	ND
	HpCDFs	0.002–0.005	ND	ND	ND	ND	ND	ND	ND
	OCDF	0.007	ND	ND	ND	ND	ND	ND	ND
Total PCDDs		–	ND	0.010	0.021	0.047	0.012	0.055	ND
Total PCDFs		–	ND	ND	ND	0.015	ND	0.068	ND
Total (PCDDs + PCDFs)		–	ND	0.010	0.021	0.062	0.012	0.12	ND
Dioxin-like polychlorinated biphenyl	Non-ortho	0.005–0.007	0.12	36	ND	0.17	ND	1.2	4.6
	Mono-ortho	0.007–0.01	68	620	0.88	1.7	0.36	13	8.8
	Total	–	69	650	0.88	1.8	0.36	14	13

TeCDDs: tetrachlorodibenzo-p-dioxins, PeCDDs: pentachlorodibenzo-p-dioxins, HxCDDs: hexachlorodibenzo-p-dioxins, HpCDDs: heptachlorodibenzo-p-dioxins, OCDD: octachlorodibenzo-p-dioxin, TCDFs: tetrachlorodibenzofurans, PeCDFs: pentachlorodibenzofurans, HxCDFs: hexachlorodibenzofurans, HpCDFs: heptachlorodibenzofurans, OCDF: octachlorodibenzofuran.
LOD = limit of detection.
ND = lower volume than the limit of detection.