Bull Environ Contam Toxicol (2008) 80:185–187
DOI 10.1007/s00128-007-9337-x

Assessment of Dioxin Intake from Commercial Baby Food in Infant

Koichi Saito · Atsuko Ohmura · Mikiko Takekuma

Received: 15 September 2007 / Accepted: 10 December 2007 / Published online: 9 January 2008

Abstract Commercial baby food was roughly classified into six food groups, including vegetable, fruit, fish, meat, dairy product, and cookie. Dioxin levels in commercial baby food were determined, and dioxin intake in infants was assessed on the basis of the proposed original model food groups. The total daily dioxin intake was 0.070 pg TEQ/kg body weight/day. The total dioxin intake in this study was considerably lower than the Tolerable daily intake (TDI) of 4 pg TEQ/kg body weight/day set by Japanese regulations. The dioxin intake from commercial baby food is considered not to be a serious problem at the moment. We believe that the proposed classification and calculation is suitable for the evaluation of total dioxin intake from commercial baby food.

Keywords Dioxin intake · Baby food · Infant · Total diet study

The exposure levels of dioxins, such as polychlorinated dibenzo-*p*-dioxins (PCDDs), dibenzofurans (PCDFs), and coplanar PCBs (Co-PCBs), in infants are thought to exceed the Tolerable daily intake (TDI) set by the World Health Organization (WHO), because of their small bodies. Actually, it is not unusual that the dioxin level in an infant who was breastfed for a short term exceeds TDI (Schecter et al. 1996). As TDI is the total amount of dioxins that can be taken by a human over an entire lifetime without posing any appreciable health risk, WHO has opined that breast-feeding presents much more advantages, including proper nourishment, immunity, and physical contact with mother, than commercial infant formula. However, in general, infants start taking baby food around the sixth month after birth. Therefore, it is feared that the dioxin level in infants who receive relatively large amounts of dioxins originating in baby food during the weaning period, in addition to the dioxins from breastfeeding, might exceed TDI even after lactation.

In our previous study of dioxin levels in breast milk collected from approximately 300 mothers in Saitama Prefecture, Japan, we found that the dioxin levels in breast milk of mothers who were nursed in infancy were significantly higher than those of mothers who received infant formula in infancy (Takekuma et al. 2004). The results indicate that dioxin intake at infancy exerted an influence even at adulthood and thus, the present TDI, which is the tolerable dioxin level based on the total dioxin intake in an entire lifetime, is considered to be insufficient for the evaluation of dioxin intake in infants. Obviously, measuring dioxin level in baby food is as important as measuring dioxin level in breast milk.

There are few reports on the residual dioxin levels in baby food (Frommberger 1993; Schecter et al. 2002; Amakura et al. 2005; Sasamoto et al. 2006). One reason why studies that assess dioxin intake from baby food are limited could be that no model food groups are available for the assessment of dioxin contamination in baby food. On the other hand, a total diet study that assessed dioxin intake from various kinds of food in adults was conducted by Tsutsumi et al. (2001). In this study, dioxin levels in

K. Saito (✉)
Faculty of Pharmaceutical Sciences, Department of Analytical Chemistry, Hoshi University, 2-4-41 Ebara, Shinagawa-ku, Tokyo 142-8501, Japan
e-mail: saitok2005@yahoo.co.jp

A. Ohmura · M. Takekuma
Biological Effect Research Group, Saitama Institute of Public Health, 639-1 Kamiokubo, Sakura-ku, Saitama-shi 338-0824, Japan

commercial baby food were determined, and dioxin intake in infants was assessed on the basis of the proposed original model food groups for baby food.

Materials and Methods

Commercial baby food was purchased at various local supermarkets in Saitama Prefecture and roughly classified into six food groups, including vegetable, fruit, fish, meat, dairy product and cookie. Dioxin contamination for each group was determined using the official Japanese method (Tentative guidelines for analysis of polychlorinated dibenzo-*p*-dioxins, dibenzofurans and coplanar PCBs in food 1999), and total daily dioxin intake from baby food was determined by taking the summation of dioxin contents in the six food groups. The outline of the analysis is as follows. Briefly, food sample was spiked with a mixture of ^{13}C-labeled PCDDs, PCDFs, and Co-PCBs as surrogate for the internal standards. The food sample was saponified by alkaline digestion and extracted with *n*-hexane. The extract was purified by multi-layer silica gel column and activated carbon/silica gel chromatography. The determination of PCDD/Fs and Co-PCBs by HRGC/HRMS was carried out according to previously described methods (Saito et al. 2003, 2006, 2007). The detection limits (pg/g) for the respective analytes were as follows: 0.01 for 4-5CDD/Fs, 0.02 for 6-7CDD/Fs, 0.05 for OCDD/F, 0.1 for non-ortho PCBs, and 1 for mono-ortho PCBs. Toxicity equivalent quantity (TEQ) was calculated using WHO-TEF (1998) (Van den Berg et al. 1998). The total daily dioxin intake in an infant (7.5 months old) was calculated as follows:

(1) When a dioxin congener was not detected (below the detection limit), the congener's concentration was set at zero.
(2) In the same case as that described above, the congener's concentration was set at half the value of each congener's detection limit.

Total dioxin intake from commercial baby food was calculated as follows:

[Total dioxin intake] = [sum of dioxin contents in five groups] × 3/5 + [amount of dioxins in one piece of cookie].

Results and Discussion

Commercial baby food was roughly classified into six food groups, including vegetable, fruit, fish, meat, dairy product, and cookie, on the basis of the classification of food groups generally used for the evaluation of dioxin intake in adults in a total diet study (Tsutsumi et al. 2001). Food examined in the total diet study of adults was classified into 13 groups, whereas baby food was roughly classified into six groups, as described above, because most of the commercial baby food products were ready-to-serve meals prepacked in a glass bottle for one meal. In order to evaluate dioxin intake from baby food, it was postulated that an infant has four meals a day: one bottle of commercial baby food for each main meal and one piece of cookie as snack. The amount of cookie consumed in 1 day was assumed to be 20 g, based on information from baby food manufacturers and questionnaires handed out to persons well experienced in childcare. Moreover, it was postulated that the five food groups except cookie were equally consumed in 1 day, and total dioxin intake from commercial baby food was calculated as follows:

[Total dioxin intake] = [sum of dioxin contents in five groups] × 3/5 + [amount of dioxins in one piece of cookie].

As for the average body weight of an infant, which was one of the indispensable parameters for the calculation of dioxin intake, 8 kg was adopted because the official investigation by the Ministry of Health, Labour and Welfare of Japan reported that the average body weight of a 7.5-month-old infant was 8 kg.

Two sets of baby food were analyzed for each food group (Table 1). Baby food products from different manufacturers were chosen. The dioxin levels in the baby food tested ranged from < 0.0001 to 0.0245 pg TEQ/g and were nearly the same for sets 1 and 2 of each food group. However, there were differences among the food groups, as shown in Table 1. The main sources of dioxin intake were dairy product and cookie, while fruit, fish, and meat had relatively low dioxin levels. A total diet study of dioxins in adult has indicated that dioxin intake is attributable mostly to fish, meat, and dairy products (Tsutsumi et al. 2001). It was also reported that dioxin levels in commercial baby food in the United States were 0.028–0.226 pg TEQ/g (Schecter et al. 2002), and the levels varied according to meat content. On the other hand, Amakura et al. (2005) reported that dioxin levels in commercial baby food in

Table 1 Dioxin levels in commercial baby food

Food group	Amount (g)		TEQ concentration (pg TEQ/g)	
	Set #1	Set #2	Set #1	Set #2
Vegetable	130	113	0.0005	0.0007
Fruit	70	71	0.0002	<0.0001
Fish	130	130	0.0002	0.0003
Meat	130	128	0.0004	< 0.0001
Dairy product	70	130	0.0088	0.0009
Cookie	20	20	0.0013	0.0245

When a dioxin congener was below the detection limit, the congener's concentration was set at zero

Table 2 Daily dioxin intake from baby food in infants

Food group	DI (pg TEQ/day) (ND = 0)	DI/BW (pg TEQ/kg bw/day)	DI (pg TEQ/day) (ND = LOD × 1/2)	DI/BW (pg TEQ/kg bw/day)
Vegetable	0.067	0.0084	3.3	0.42
Fruit	0.006	0.0008	1.9	0.23
Fish	0.031	0.0039	3.5	0.44
Meat	0.029	0.0037	3.5	0.44
Dairy product	0.367	0.0459	2.9	0.37
Cookie	0.258	0.0322	0.7	0.09
Total intake[a]	0.56	0.070	9.8	1.2

DI (Daily intake) and DI/BW (daily intake/body weight) were calculated from the average of Sets #1 and #2

Body weight of a 7.5-month-old infant was set at 8 kg

[a] Total dioxin intake = (sum of dioxin contents in groups 1–5) × 3/5 + group 6

Japan were <0.001–0.135 pg TEQ/g and varied depending on fish and/or dairy product content.

The total daily dioxin intake per kg body weight was 0.070 pg TEQ/kg bw/day (ND = 0), or 1.2 pg TEQ/kg bw/day (ND = LOD × 1/2) as shown in Table 2. Another investigation by Amakura et al. (2005) showed that the total daily dioxin intake was 0.686 pg TEQ/kg bw/day when the average value of 0.016 pg TEQ/g was used in the calculation. They postulated that an infant consumes 300 g of baby food a day (3 times a day × 100 g of baby food per meal) and that the body weight is 7 kg.

On the other hand, Sasamoto et al. (2006) reported that the daily dioxin intake was 0.32–1.25 pg TEQ/kg bw/day when the infant meal consisted of half of homemade baby food and half of commercial baby food. The total dioxin intake in this study was considerably lower than the data described above and the TDI of 4 pg TEQ/kg bw/day set by Japanese regulations. We think that the difference in data is due to the difference in raw material used, such as fish, meat, vegetable, and dairy products.

Numerous investigations have revealed that dioxin levels in breast milk or food are on the decline ever since various measures were taken against the so-called "dioxin crisis" that ensued in Japan in this decade. The low dioxin levels in baby food may reflect a decrease in dioxin levels in the atmosphere. On the basis of these results, the dioxin intake from commercial baby food is considered not to be a serious problem at the moment. We believe that the proposed classification and calculation is suitable for the evaluation of total dioxin intake from commercial baby food.

References

Amakura Y, Tsutsumi T, Iida T, Nakagawa R, Hori T, Tobiishi K, Uchibe H, Nakamura M, Yanagi T, Kono Y, Toyoda M, Sasaki K, Maitani T (2005) Contamination levels of PCDDs, PCDFs and Co-PCBs in commercial baby foods in Japan. J Food Hyg Soc Japan 46:148–152

Frommberger R (1993) Intake of dioxins and furans by babies via commercial baby foods in comparison to human milk. Deutsche Lebensmittel-Rundschau 89:137–142

Saito K, Takekuma M, Ogawa M, Kobayashi S, Sugawara Y, Ishizuka M, Nakazawa H, Matsuki Y (2003) Enzyme-linked immunosorbent assay toxicity evaluation method for dioxins in human milk. Bull Environ Contam Toxicol 70:636–643

Saito K, Ohmura A, Takekuma M, Fukui M, Iwasaki Y, Ito R, Matsuki Y, Nakazawa H (2006) Evaluation of toxic equivalent quantity of dioxins in human milk using different toxicity equivalence factors. Bull Environ Contam Toxicol 76:641–647

Saito K, Ohmura A, Takekuma M, Sasano R, Matsuki Y, Nakazawa H (2007) Application of a novel large-volume injection method using a stomach-shaped inlet liner in capillary gas chromatographic trace analysis of dioxins in human milk and plasma. Anal Sci 23:661–665

Sasamoto T, Tatebe H, Yamaki Y, Hashimoto T, Ushio F, Ibe A (2006) Estimation of daily intake of PCDDs, PCDFs and Co-PCBs from baby foods. J Food Hyg Soc Japan 47:157–163

Schecter A, Paepke O, Lis A, Ball M, Rayan JJ, Olson JR, Li L, Kessler H (1996) Decrease in milk and blood dioxin levels over two years in a mother nursing twins: estimates of decreased maternal and increased infant dioxin body burden from nursing. Chemosphere 32:543–549

Schecter A, Wallace D, Pavuk M, Piskac A, Paepke O (2002) Dioxins in commercial United States baby food. J Toxicol Environ Health A 65:1937–1943

Takekuma M, Saito K, Ogawa M, Matsumoto R, Kobayashi S (2004) Levels of PCDDs, PCDFs and Co-PCBs in human milk in Saitama, Japan, and epidemiological research. Chemosphere 54:127–135

Tentative guidelines for analysis of polychlorinated dibenzo-*p*-dioxins, dibenzofurans and coplanar PCBs in food, September, 1999, Environmental Health Bureau, Ministry of Health and Welfare, Japan

Tsutsumi T, Yanagi T, Nakamura M, Kono Y, Uchiba H, Iida T, Hori T, Nakagawa R, Tobiishi K, Matsuda R, Sasaki K, Toyoda M (2001) Update of daily intake of PCDDs, PCDFs, and dioxin-like PCBs from from food in Japan. Chemosphere 45:1129–1137

Van den Berg M, Birnbaum L, Bosveld ATC, Brunström B, Cook P, Feeley M, Giesy JP, Hanberg A, Hasegawa R, Kennedy SW, Kubiak T, Larsen JC, van Leeuwen FXR, Liem AKD, Nolt C, Peterson RE, Poellinger L, Safe S, Schrenk D, Tillitt D, Tysklind M, Younes M, Waern F, Zacharewski T (1998) Toxic equivalency factors (TEFs) for PCBs, PCDDs, PCDFs for humans and wildlife. Environ Health Perspect 106:775–791