DIETARY INTAKE OF POLYCHLORINATED DIBENZO-*p*-DIOXINS, DIBENZOFURANS AND POLYCHLORINATED BIPHENYLS IN SWEDISH CONSUMERS

Emma Ankarberg, Gabriela Concha, Per Ola Darnerud, Marie Aune, Anna Törnkvist and Anders Glynn
Swedish National Food Administration, Research and Development Department, P.O. Box 622, SE-751 26 Uppsala, Sweden

Abstract
The main objective of the study was to calculate the dietary intake of polychlorinated dibenzo-*p*-dioxins (PCDDs), dibenzofurans (PCDFs) and dioxin-like polychlorinated biphenyls (dl-PCBs) and the relative contribution of different food groups to the TEQ-intake in Swedish consumers.

Occurrence data of PCDD/Fs and dl-PCBs in food products consumed in Sweden were collected in different projects during 1999-2004. PCDD/F and dl-PCB-concentrations were determined in fish, shellfish, meat products, eggs, dairy products and fats. Dietary intake of PCDD/F and dl-PCB-concentrations was calculated by combining concentrations of the contaminants in food products with data from national food surveys conducted in 1998 on adults (n=1212, age 17-79 yrs) and in 2003 on children (n=2448, age 4-12 yrs).

Median total dietary intake of PCDD/Fs and dl-PCBs for the general adult population in Sweden was 1.1 pg WHO-TEQ/kg bw/day and for the children 1.2 – 2.3 pg WHO-TEQ/kg bw/day depending on age. For the adults, fish and shellfish contributed with 43 % to the TEQ-intake, while the contribution from dairy products and meat products was 20 % and 14 %, respectively. For children, fish and shellfish contributed with 32-35 % to the TEQ-intake. Dairy products and meat contributed with 20-26 % and 27-32 %, respectively.

Introduction

For many organic halogenated environmental contaminants, diet is the most common exposure route for humans. More than 90% of the human exposure to PCDD/Fs is estimated to come from food[1].

Most fish species available on the Swedish market have low levels of environmental pollutants. However, the levels of PCDD/Fs and PCBs in fatty fish from the Baltic Sea area are still of major concern in Sweden, although the levels have decreased since the 1970's. During later years however, this decrease seems to have leveled off, and dioxin levels in Baltic herring have not decreased during the last decade. A National Food Administration (NFA) dietary study from the late 1990s[2], showed that women between the ages of 17-44 years ate herring on average four times per year, which is well below the recommended maximum average intake (of once a month). The average consumption of Baltic salmon was about two times per year. Approximately 14% of women in the age group 17-44 years were classified as high consumers, i.e., with a consumption of herring and Baltic salmon in excess of the recommended one time per month.

Materials and Methods

Dietary calculations

The dietary survey for adults was performed in 1997-98 in Sweden[2]. In total, 1212 persons (17-79 years) participated in the study. For each individual, data on sex, age and body weight were collected. The survey was divided in two parts, a 7-day diary with registration of the food consumption, and a questionnaire with detailed questions about fish consumption. The diaries and the questionnaires were equally distributed over the week and over a whole year.
The food consumption study for children was performed in 2003 in Sweden[3]. The study involved 590 4-year-old children, 889 8-9-year-old children and 1016 11-12-year-old children. The study was divided into a 4-day diary and a questionnaire. The diaries and the questionnaires were equally distributed over the week and over a whole year.
From the compiled data of the diary and questionnaire, the individual consumption of the different food groups was calculated. The consumption data was combined with PCDD/F and dl-PCB levels to calculate the WHO-TEQ intake from food.

Food sampling and preparation

Levels of PCDD/Fs and dl-PCBs in vegetable fat, other fat, chicken, game, sausages, tuna fish and sardines were obtained from a market basket study in 1999[4]. The food products were purchased in four major Swedish cities (Malmoe, Gothenburg, Uppsala and Sundsvall). Levels of PCDD/Fs and dl-PCBs in cow's milk, egg, beef and pork were obtained from the Swedish NFA's control program for dioxins 2003-2004, and the samples came from different parts of Sweden. Data on seafood, herring, mackerel, salmon, eel and cod were obtained from a NFA fish-project in 2000-2003. The sampling design was intended to cover areas in Sweden where fatty fish are caught on commercial basis as well as in areas where the public perform angling.

Chemical analysis

17 PCDD/F congeners and the PCB congeners 77, 81, 105, 114, 118, 126, 156, 157, 167 and 169 were analyzed. The PCDD/Fs and non-ortho PBCs were analyzed according to a validated method at Umeå University, Sweden. The analyses of the mono-ortho PCBs were performed according to a validated method at NFA, Uppsala, Sweden. The PCDD/DF and PCB levels were expressed in pg WHO-TEQ/g fresh weight according to the WHO TEFs for human risk assessment[5]. When calculating the WHO-TEQ values, the medium-bound level has been used for non-detects (n.d.=½ LOQ). The average TEQ-value for herring was weighed according to landing data from the Swedish National Board of Fisheries. The TEQ-value for seafood was weighed according to intake data for different kinds of seafood from the Swedish Board of Agriculture.

Results and Discussion

Intake calculations

Adults

Median dietary intake of PCDD/Fs and dl-PCBs for the general adult population in Sweden was 1.1 pg WHO-TEQ/ kg bw/day. Fish and shellfish contributed with 43 % to the total intake, dairy products with 20 % and meat with 14 % (Table 1).

Table 1. Intake of PCDD/Fs and dl-PCBs (WHO-TEQ) in all adult consumers, including contribution of different food groups to the intake in % (n = 1185).

Intake of WHO-TEQ (pg/day) for all consumers				
	Mean	Median	95:th percentile	% of total intake (median)
Fatty Baltic fish	28.3	10.9	100	18
Other fatty fish	13.8	7.75	45.5	13
Lean fish	7.52	6.14	17.3	10
Seafood	4.82	0.95	15.1	1.6
Fish	**54.4**	**34.7**	**157**	**43**
Meat and poultry	9.65	8.46	20.8	14
Dairy products	13.6	12.1	28.6	20
Vegetable fat	7.93	5.58	22.6	9.4
Other fat	8.04	7.01	18.7	12
Egg	0.02	0.47	2.83	0.8
Total intake				
pg/day	**94.4**	**75.1**	**204**	
pg/kg bw/day	**1.30**	**1.07**	**2.85**	

The contribution from Baltic fish was especially notable in men and older women (>40 years; results are not shown).

Calculations showed that 4.8 % of the women in childbearing age (17-40 yrs) had intake levels above the tolerable weekly intake (TWI) for PCDD/Fs and dl-PCBs of 14 pg WHO-TEQ/kg bw/week[6]. Among these women, 69% did not follow the NFA dietary advice regarding fatty fish from the Baltic Sea.

Compared to earlier intake estimations this present study shows a small reduction in the TEQ intake among Swedish consumers. This reduction is probably due to decreased concentrations of PCDD/Fs and dl-PCBs in the different foodstuffs.

Children
The median intake of PCDD/Fs and dl-PCBs (WHO-TEQ) among the 4-year-old girls was 2.3 pg/kg bw/day, and 2.4 pg/kg bw/day for the boys. Girls aged 8-9 years and 11-12 years, had an intake of 1.8 and 1.2 pg/kg bw/day, respectively. For boys at the same age, the intakes were 1.9 and 1.3 pg/kg bw/day, respectively (Table 2). No gender differences in the TEQ intake were seen.
Fish and shellfish contributed with 32 – 35 % to the total intake of PCDD/Fs and dl-PCBs among children. Meat and meat products contributed with 27 – 32 % and dairy products with 20 – 26 %.

Table 2. Intake of PCDD/Fs and dl-PCBs (WHO-TEQ) in children.

	pg/day		**pg per kg bw/day**	
	Girls	Boys	Girls	Boys
4 – year olds				
Mean	46.4	48.2	2.6	2.6
Median	41.4	43.6	2.3	2.4
95 percentile	91.2	89.1	4.8	4.8
N	286	298	260	262
8-9 year olds				
Mean	62.6	67.0	2.1	2.2
Median	53.5	59.1	1.8	1.9
95 percentile	130	133	4.2	4.2
N	432	440	398	389
11-12 year olds				
Mean	56.0	64.7	1.4	1.6
Median	47.1	54.6	1.2	1.3
95 percentile	120	117	3.0	2.9
N	486	506	465	484

In this study, 65 % of the 4-year-old children, 41 % of the 8-9-year-old children and 14 % of the 11-12-year-old children had an intake that exceeded the TWI of PCDD/Fs and dl-PCBs. Also for children, fish and shellfish contributed considerably to the TEQ-intake but not as much as for the adult consumers. The dietary recommendations regarding salmon and herring from the Baltic Sea (not more than once a month for girls and women in child-bearing age) were followed by most of the girls. Only 2.5 – 4.5 % of the girls stated that they consumed Baltic salmon more often than once a month. The consumption of Baltic salmon was probably overestimated, since it is very hard to find Baltic salmon on the Swedish market.

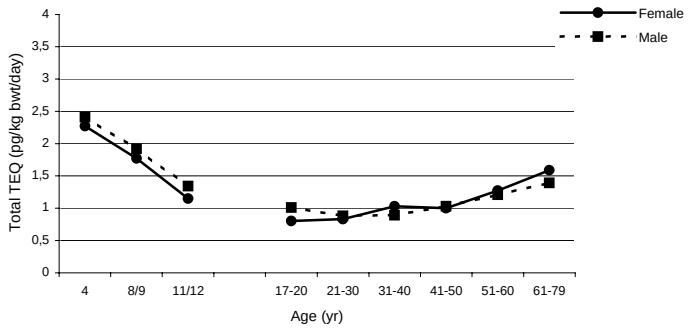

Figure 1. Median intake of WHO-TEQ (pg/kg bw/day)[7].

These studies show that the median intake levels of PCDD/Fs and dl-PCBs in Swedish consumers are well below the tolerable weekly intake of 14 pg WHO-TEQ/kg bw for adults, but slightly over the tolerable weekly intake for children. The WHO-TEQ-intake for children decreases with age when the intake is calculated by bodyweight (Figure 1). This is due to the diluting effects weight gain has on the intake levels of PCDD/Fs and dl-PCBs. In relation to their body weight, children eat more food than adults, and this leads to higher intake levels.
The median intake of PCDD/Fs and dl-PCBs per kg bw for the 4-year-old children is twice the intake for adults, however, the median intake for the 11-12-year-old children is in the same range as for adults.

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