Dioxin Mass Balance for the City of Hamburg, Germany: Part 3: Update of Food Consumption Data and Human Exposure

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Abstract

The exposure of humans to polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/PCDF) was calculated for a 25-50 year model person on the basis of recent German food consumption data. Due to the strong accumulation of PCDD/PCDF in fatty tissues, the consumption of meat, milk, and fish causes 85 % of the total dietary intake. The dioxin intake via food consumption accounts to 100 pg I-TEQ/d or 1.43 pg I-TEQ/(kg bw·d) for the average 70 kg person. The contribution for meat, milk, and fish was calculated to be 37, 32 and 17 %, respectively. Uptake from environmental compartments (<< 5 %) is usually negligible.

The evaluation of the socio-demographic data (sex, age, education, place of residence) gave the following results: the regional preferences for the various food categories and individual eating habits cause 25-40 % variations and thus, are more important than the location of purchase. Consequently, human exposure to dioxins in Hamburg is not different from the average value in Germany. Evaluation of food-specific PCDD/PCDF concentrations in connection with consumption habits is of increasing importance, as the dioxin levels in food items are decreasing.

1 INTRODUCTION

Calculations of PCDD/PCDF exposure for Germany and other industrialized countries came to a relatively small range of about 120-150 pg I-TEQ per day and person [1-3], resulting in a daily intake of approximately 2 pg I-TEQ/kg body weight (bw). Data from Canada and the Netherlands indicated lower exposures of less than 100 pg I-TEQ/d [4] and even 1 pg I-TEQ/(kg bw·d) [5], respectively. In addition, a decrease of PCDD/PCDF concentrations in human blood, breast milk and adipose tissue was observed over the last years [6]. These findings ask for a reevaluation of human exposure towards dioxins for the German population based on recent PCDD/PCDF concentrations in foodstuffs.

2 METHODS

Within the Dioxin Mass Balance for Hamburg [25], we calculated the PCDD/PCDF intake by first evaluating the amount of foodstuffs eaten on a fresh weight and on a fat basis [7,8]. The results were deduced from pooled data as found in the National Consumption Study (NVS; nationale Verzehrsstudie). The dioxin intake was then calculated by combining the NVS consumption data with recent PCDD/PCDF concentrations in the various foodstuffs.

3 PCDD/PCDF EXPOSURE THROUGH FOODSTUFFS

3.1 Milk and Dairy Products

PCDD/PCDF concentrations in milkfat decreased during the last years: Whereas in 1992 a level of 1.8 pg I-TEQ/g milkfat was typical for Germany [9-10], recent studies found lower levels of 1.37 [11], 1.30 [12] and 1.2 pg I-TEQ/g milkfat [13]. In the years 1993 and 1994, in the federal states of Hessia and Northrhine-Westphalia concentrations continued to decrease below 1 pg I-TEQ/g milkfat [26,27]. The precaution value of 0.9 pg I-TEQ/g milkfat as set by German state and federal expert councils [9] was met.

In our calcuation, we used an average value of 1.0 pg I-TEQ/g fat [13] for milk products predominantly produced in Germany. Since production and consumption localities of foodstuffs are largely decoupled in Germany (as in other industrialized countries, too), we can assume an almost even distribution of PCDD/PCDF concentrations in milk products and thus, local variations caused by contaminated areas are negligible for the exposure of the average consumer.

In contrast to milk, dairy products (butter, cheese, yoghurt, etc.) are supplied for the German market to a considerable extent by other countries of the European Union (EU). For these products a more conservative mean value of 1.2 pg I-TEQ/g fat was applied, due to the fact that measures to decrease PCDD/PCDF emissions are not as advanced in all EU countries as in Germany.

3.2 Meat and meat products

Reports showing a significant decrease of PCDD/PCDF levels in meat and meat products are not available for Germany, so that we used an average PCDD/PCDF content of 0.7 pg I-TEQ/g fat in sausages and 0.3 pg I-TEQ/g fat in pork. The higher concentration for sausages was applied because many products contain both, pork and beef. The share of beef (2.7 pg I-TEQ/g fat) in minced meat is at least 50 %, so that a PCDD/PCDF content of 1.5 pg I-TEQ/g fat was used. PCDD/PCDF concentrations in the fat of innards amount to an average value of 8 pg I-TEQ/g fat (calculated on data from [5,17]).

3.3 Fish and fish products

Compared to other animal fat, fish fat shows a considerably higher PCDD/PCDF content. Higher than average fish consumption may cause higher body-burden[18,19]. The average consumption in Germany is 14.5 kg/a on a fillet weight [19]; however, coastal inhabitants consume 30 kg/a, interiors only 4-5 kg/a. Higher fish consumption (35-88 kg/a [19]) than in Germany is found in countries with longer coastlines.

These differences cause a variable share of fish to the whole exposure between 10 and 40 % (Japan 60 % [20]) depending on residence.

Former calculations in Germany were carried out - as far as there were no explicit data on single fish species available - with a PCDD/PCDF concentration of 35 pg I-TEQ/g fat. At a consumption of about 1 g fat per day the exposure was 34 pg I-TEQ/d and 25-30 % of the whole exposure. Based on species and origin specific PCDD/PCDF contents of the mainly consumed species and their consumption market segments for the adult male population, an exposure of 10-20 pg I-TEQ/d was derived [21]. This is in agreement with other studies [5,23,24] which report levels of 10-15 pg I-TEQ/g fat.

3.4 Other foodstuffs and summary of results

In terms of PCDD/PCDF exposure, other foodstuffs (except eggs) are of minor importance. Such foodstuffs are either of plant origin, low in fat content or do not have a high potential for bioaccumulation of lipophilic compounds. A summary of the PCDD/PCDF intake via food for men and women in Germany is given in Table 1.

Table 1: PCDD/PCDF intake via food: Aggregated data and results from sections 3.1 to 3.4

	Consumption		Concentration	Intake	
	Men g fat/d	Women g fat/d	PCDD/PCDF pg I-TEQ/g fat	Men pg I-TEQ/d	Women pg I-TEQ/d
- Milk	7.2	7.1	1.0	7.2	7.1
- Cheese and cottage cheese	8.0	6.6	1.2	9.6	7.9
- Butter	17.1	14.0	1.2	20.5	16.8
Sum from milk and dairy products	*32.3*	*27.7*		*37.3*	*31.8*
- Meat	10.6	5.9	0.3-2.7	14.7	5.7 [b]
- Meat products and sausages	35.0	22.2	0.7-8.0	31.6	21.3
Sum from meat and meat products	*45.6*	*28.1*		*46.3*	*27.0*
Sum from fish, fish products, seafood	*1.6*	*1.1*	*12.0-68.1*	*19.7*	*14.3*
- Eggs	4.4	3.7	1.5	6.6	5.6
- Edible fat and oils	20.5	15.4	0.02-0.3	0.9	0.6
Sum from eggs, edible fat, oil	*24.8*	*19.1*		*7.6*	*6.3*
Sum from fatty foodstuff	*104.3*	*76*		*110.9*	*79.4*
		Both Sexes g (fw)/d [a]	pg I-TEQ/g(fw)		
Sum from non-fatty foodstuffs		*603.2*	*0.007-0.02*	*6.9*	*6.9*
Grand total from foodstuffs				**117.8**	**86.3**
Body weight (kg)				78.0	62.0
Relative daily exposure per kg bw (pg I-TEQ/kg bw)				**1.51**	**1.39**

a) fw = fresh weight; b) relatively more pork meat

3.5 Regional and educational variations of eating habits

Milk, meat, fish, and derived products were identified to be responsible for approximately 85 % of the daily PCDD/PCDF exposure for the general German population. However, there are regional differences in eating habits and thus, PCDD/PCDF intake due to preferred foodstuffs may occur in the range of up to 30 % for the various food categories (see Table 2). As can be seen from Table 2, too, the overall daily PCDD/PCDF intake is very similar for all regions and cities considered. In other words: The different levels of PCDD/PCDF in several categories of foodstuffs are more or less compensated by the eating habits due to the geographical variance within Germany; *e.g.* higher milk consumption in the north than in the south, or higher dioxin intake from meat in Munich than in Hamburg or Düsseldorf.

Table 2: PCDD/PCDF exposure (pg I-TEQ/d) through selected categories of foodstuffs in different German regions and larger cities.

Food Category	Geographical Region				Cities		
	Northern	Western	Middle	Southern	Hamburg	Düsseldorf	Munich
Milk and dairy products	39.4	36.1	31.3	31.3	37.7	33.6	31.8
Meat and meat products	32.0	33.4	38.4	42.4	29.7	33.9	41.2
Fish and fish products	20.1	17.6	15.8	14.5	24.1	17.2	17.9
Total	**91.5**	**87.1**	**85.5**	**88.2**	**91.5**	**84.7**	**90.9**

Education can be taken as another parameter to evaluate PCDD/PCDF exposure via foodstuffs. We classified our standard population into four categories of education: persons with a lower education (primary school or less) and higher education (middle school, high school, university degree). It could be shown that persons with a lower education consumed 8-10 % more fat than persons of a higher education. In addition, with an increasing level of education, the exposure pathways shift from high consumption of meat and sausages towards milk and dairy products; the latter being considered to be healthier than the fatty meat products. With regard to single categories of foodstuffs, variations of up to 40 % could be determined due to educational influenced eating habits.

4 DISCUSSION

Recent data on PCDD/PCDF levels in food from Germany and other industrialized countries showed a downward trend. This fact is due to installation of pollution control technologies and legal measures to reduce dioxin emissions into the environment. As a result, ambient air dioxin concentrations decreased and thus, the impact to the agricultural food-chain grass → cattle (meat and milk) → humans as well as soil → chicken/eggs → humans nowadays is lower than it was in the past. Evaluating dioxin exposure of the German population showed that today's daily intake of PCDD/PCDF (117.7 pg I-TEQ/d for men and 86.2 pg I-TEQ/d for women) is lower than was reported before (130 pg I-TEQ/d) [2]. The „Dioxin Mass Balance for Hamburg" gave conclusive results that dioxin intake may be highly variable for individuals due to a) regional eating habits and b) educational influence, resulting in a lower intake of fat from meat and meat products. Presently, the overall PCDD/PCDF intake from all foodstuffs almost compensates the different levels of dioxin contamination of the various food categories. As a result, the daily PCDD/PCDF intake for the general German population was determined to be 1.51 pg I-TEQ/(kg bw·d) for men and 1.39 pg I-TEQ/(kg bw·d) for women. Significant regional differences between people living in northern and southern parts of Germany could not be identified.

If in the future additional measures are taken and/or dioxin emission control technologies (e.g. flue gas cleaning devices, implementation of sewer treatment plants, ban of dioxin contaminated products, remediation of containated soils and sediments, etc.) will be applied worldwide, these efforts will result in further lowering the PCDD/PCDF levels in foodstuffs. Thus, the precaution value of 1 pg I-TEQ per kg of body weight and day for external exposure of the general population as set by German state and federal expert councils can be met.

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