PCDDs, PCDFs AND PCBs IN FOOD FROM THE IRKUTSK OBLAST, RUSSIA

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Introduction

Food has been found to be the primary source of polychlorinated dibenzo-p-dioxins (PCDDs), dibenzofurans (PCDFs) and biphenyls (PCBs) to the general population in many industrialized countries (1). Food of animal origin, and animal fat in particular, account for most of the exposure.

Studies of the aquatic food chain in Lake Baikal have revealed surprisingly high levels of organochlorine contaminants. PCB concentrations in fish and seals from Lake Baikal have been determined going back to 1981 (2), and the congener specific PCB contamination of the aquatic food chain has been studied (3,4). Recently, the first data on the levels of PCDD/Fs in the Lake Baikal ecosystem were also published (5).

There is presently little information on the levels of these compounds in food produced in the Irkutsk Oblast. The only data that we are aware of are a few supermarket samples from the cities of Baikalsk and Irkutsk that were analyzed by Schecter and coworkers (6,7). The purpose of this study was to expand this data base, focusing on food of animal origin produced in the Irkutsk Oblast.

Material and Methods

Samples of milk, butter, beef fat, pork fat and chicken meat were analyzed (see Table).

Table: Characteristics of the food samples from the Irkutsk Oblast.

No.	Sample	Sampling Site	Time of sampling	Lipid Content (% of wet weight)
1	Milk (raw)	Irkutsk	14.08.1997	1.7
2	Milk (raw)	Angarsk	18.08.1997	3.6
3	Milk (raw)	Usol'ye-Sibirskoe	12.08 1997	3.3
4	Milk (packaged)	Irkutsk	14.08.1997	1.5
5	Milk (packaged)	Angarsk	18.08.1997	3.6
6	Milk (packaged)	Usol'ye-Sibirskoe	12.08.1997	2.8
7	Chicken meat	Angarsk	19.08.1997	14.9
8	Butter	Irkutsk	14.08.1997	74.0
9	Beef fat	Irkutsk Oblast	14.08.1997	86.5
10	Pork fat	Irkutsk Oblast	14.08.1997	93.6

All samples were collected with the help of the State Sanitary-Epidemiological Service. Milk was collected from three dairies in Irkutsk, Angarsk and Usol'ye Sibirskoe. Each of these dairies was very large, so the milk samples should give a good indication of the regional contamination. Both raw milk (the milk as delivered from the farms) and packaged milk were analyzed. The dairies use different kinds of packaging. The following were used in our investigations: Paper cartons lined with aluminum foil in Irkutsk; unlined paper cartons in Angarsk; and polyethylene bags in Usol'ye Sibirskoe. A butter sample from the Irkutsk dairy was also analyzed.

The meat samples were also collected so as to be representative for a large area. The chicken was sampled from one of the largest Angarsk poultry factories. The beef sample contained beef fat collected from the Ust-Orda, Bayandai, Nukuty and Ekhirit-Bulagat areas of the Irkutsk Oblast. Pork fat was sampled from the Ust-Orda and Ekhirit-Bulagat areas.

The bulk milk was collected in glass bottles. The butter, chicken, beef and pork were wrapped in pre-washed aluminum foil. All of the samples were frozen and stored at -20°C until they were analyzed at the University of Bayreuth, Germany. The analysis was conducted using previously published methods (5) with some modifications to account for the different matrices. Both the PCDD/Fs and the PCBs were measured using HRGC/HRMS at a mass resolution of 8,000-10,000. The 2,3,7,8-substituted PCDD/F congeners and PCB congeners 28, 52, 77, 99, 101, 105, 118, 126, 138, 153, 156, 169, 170, 180, 199, 202 and 209 were quantified. The toxicity equivalents (TEQs) were calculated using the TEFs for mammals recently proposed by the WHO working group.

Results and Discussion

In Figure 1 the TEQs for the PCDDs, PCDFs and PCBs are shown for the milk samples.

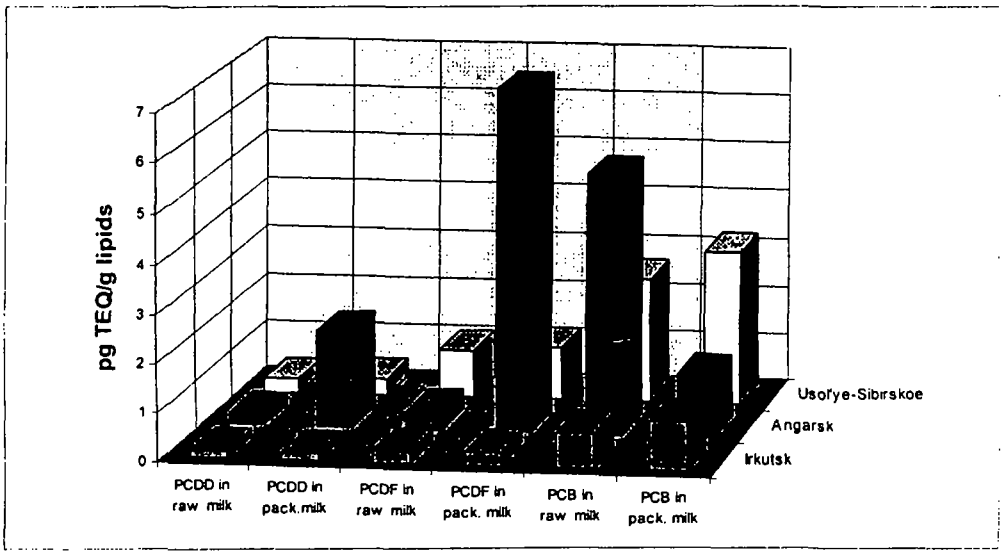

Figure 1. TEQs for the PCDDs, PCDFs and PCBs in raw and packaged cow milk from Irkutsk, Angarsk and Usol'ye-Sibirskoe.

Looking first at the raw milk samples, the PCDD and PCDF TEQs are seen to increase from the front of the figure to the back, rising from 0.14 and 0.25 pg/g lipid in the sample from Irkutsk to 0.31 and 1.00 pg/g lipid in the Usol'ye-Sibirskoe sample. The same trend was observed for the PCDD/F TEQs in soil samples from these three cities (8), suggesting that the difference in levels in the milk is due to differences in the environmental contamination. A different behavior was observed for the PCBs: While the TEQ was also higher in Usol'ye-Sibirskoe than in Irkutsk, the maximum value was measured in the Angarsk sample (5.3 pg/g lipid). This does not agree with the soil data, and no explanation can be offered at this time.

The influence of milk packaging on the contaminant levels can be seen by comparing the sample pairs in a given row of Figure 1. The raw milk and packaged milk samples from Irkutsk (paper cartons lined with aluminum) and Usol'ye-Sibirskoe (polyethylene bags) show similar TEQ levels for all 3 of the compound groups, indicating that these forms of packaging have little influence on the contaminant levels. However, in the Angarsk samples the PCDD and PCDF TEQs were twice as high in the packaged milk than in the raw milk. This increase was mainly due to the increase of 2,3,7,8-TCDD (from 0.07 to 1.9 pg/g lipid) and 2,3,7,8-TCDF (from 0.09 to 66 pg/g lipid). It is known that these isomers are characteristic of the PCDD/F contamination that results from the use of chlorine bleaching during paper production (9), and paper milk cartons made from chlorine bleached pulp have been shown to result in contamination of the milk with these congeners (10).

The total TEQ in the packaged milk sample from Irkutsk was 1.44 pg/g lipid, well below the maximum permissible concentration in Russia of 5.2 pg/g. In the sample from Usol'ye-Sibirskoe the total TEQ was 4.6 pg/g, which is very close to the statutory limit. This is cause for concern and indicates that the environmental contamination of this region with PCDD/Fs and PCBs has reached disturbing proportions. The packaged milk from Angarsk contained 10.3 pg/g lipid, clearly exceeding the statutory limit and illustrating the importance of milk cartons made from chlorine bleached pulp as a source of human exposure.

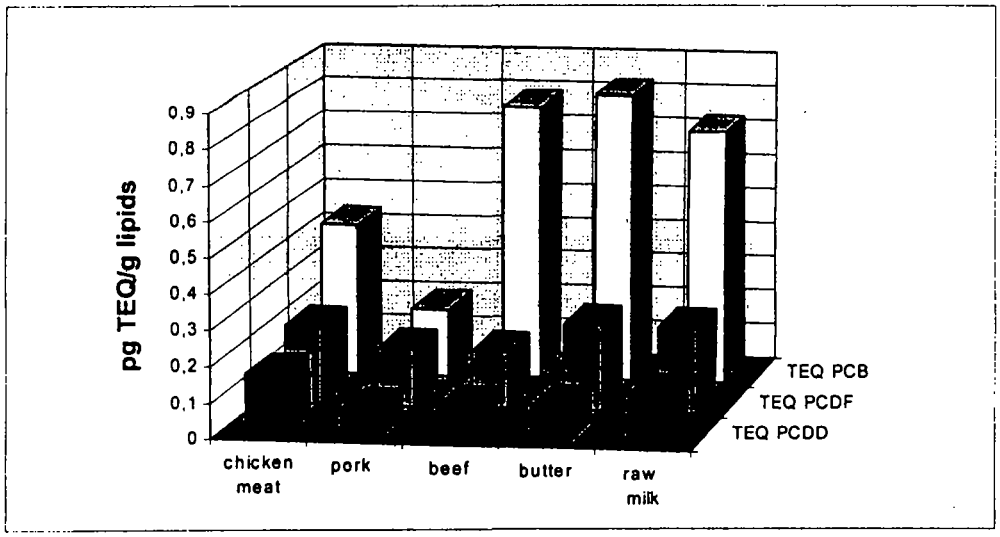

Figure 2. TEQs for the PCDDs, PCDFs and PCBs in meat and butter from the Irkutsk Oblast.

In Figure 2 the TEQs for the PCDDs, PCDFs and PCBs are shown for the butter, pork, beef and chicken samples. The raw milk sample from the Irkutsk dairy where the butter samples was taken is included for comparison purposes. The levels of all 3 contaminant groups are similar in the butter and the milk as would be expected. The levels in the beef are also similar to those in the milk and butter. The pork and chicken samples contained similar concentrations of PCDD and PCDF TEQs too, while the PCB levels were somewhat lower. The PCBs made the largest contribution to the overall TEQ in all samples. This is also typical for the adipose tissue of people living in the Irkutsk Oblast (11). The levels in all samples were well below the Russian limit of 3.3 pg/g lipid for meat and meat products. They were also low compared to values reported for other regions. For instance, the PCDD/F TEQ in pork fat was 0.24 pg/g lipid in this study, 0.49 pg/g in Ufa (Bashkortostan), 0.43-0.50 in Germany, 0.20 in Canada and 0.43 in Holland (12).

The PCDD TEQs are dominated by 2,3,7,8-TCDD and 1,2,3,7,8-PeCDD, while 2,3,4,7,8-PeCDF dominates the PCDF TEQs and PCB 126 the PCB TEQs. The relative contributions are similar for most of the samples. The most notable exception is the packaged milk from Angarsk, where 2,3,7,8-TCDD and 2,3,7,8-TCDF completely dominated their respective groups. Also of note are the comparatively high contributions of 2,3,7,8-TCDF and 1,2,3,7,8-PeCDF in chicken, a result of the greater persistence of these congeners in this species.

Acknowledgments

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