

Letter to the Editor

Polychlorinated Biphenyls in Human Milk, UHT Cow's Milk and Infant Formulas

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Abstract

The content of polychlorinated biphenyls was determined in human milk collected from four regions of Poland, as well as in cow's milk and infant formulas.

Significant statistical differences in PCB levels were determined in human milk depending on the region. The highest PCB mean concentration (0.351 mg kg⁻¹ milk fat) was determined in human milk from Gdańsk.

An average of 0.218 mg PCB kg⁻¹ milk fat was determined in human milk, 6 and 17 times higher than cow's milk and infant formulas, respectively. Higher (37%) content of PCB was found in the milk of women living in rural regions.

Keywords: PCB, human milk, cow's milk, infant formulas.

Introduction

Polychlorinated biphenyls (PCB) make up a group of synthetic chemical compounds that advanced industrialization has widely spread in the natural environment. PCBs were intensively produced world-wide in 1950-70, including the nitrogen plant in Tarnów, Poland. These liquid compounds constitute a mixture of isomers and congeners with a different number of chlorine atoms and demonstrate resistance to the activity of acids and bases. They are characterized by stability at high temperatures and good stable dielectric properties. They have been applied mainly as dielectric fluids for transformers and condensers and as hydraulic fluids. They have also been used in the electrical, rubber and paper industries as well as for the production of paints, lacquers and plastics [1].

In some countries, PCBs have been used as pesticides as they are good solvents of "proper" herbicides. Spraying of fields and forests has posed a high risk of contamination to the biosphere. Winds and surface waters have been held responsible for spreading these xenobiotics [2]. PCBs are compounds characterized by a capacity for bio-accumulation, inducing toxic effects and long-distance atmospheric transport. Therefore, they occur in places where they have not been used [3]. Due to their physical and chemical properties, they have been acknowledged as the so-called POPs – Persistent Organic Pollutants [4, 5]. The application of PCBs has resulted in their dissemination to all elements of the environment. Organisms constituting subsequent links of the food chain have been found to accumulate increasing amounts of those compounds in their tissues. Humans are the final element in the food chain; therefore, human tissues have been reported to demonstrate the highest levels of PCBs (0.8559 mg/kg) [6, 7].

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Table 1. Average PCB content in human milk in different countries in 1980-2000 (mg·kg⁻¹ of milk fat).

Country	Year	Σ PCB	Reference
Poland	1980-81	0.490	Juszkiewicz, Niewiadowska 1984 [16]
Poland	1987	0.380	Sitarska et al. 1987 [28]
Slovak Rep.	1989-92	0.577	Uhnak et al. 1993 [29]
Norway	1991	0.372	Johansen, Becher 1994 [30]
Sweden	1992	0.380	Lunden, Noren 1998 [31]
Poland	1993	0.723	Czaja, Ludwicki 1993 [32]
Slovak Rep.	1995	0.379	Prachar et al. 1996 [33]
Czech Rep.	1996	0.494	Kredl et al. 1997 [34]
Germany	1995-97	0.502	Schade, Heinzow 1998 [27]
Sweden	1997	0.324	Noren, Meironyte 2000 [26]
Poland	2000	0.113	Lulek et al. 2002 [24]
Poland	1999-2000	0.218	This study

Apart from many other environmental pollutants, polychlorinated biphenyls exert a detrimental effect on the health of humans and animals. For instance, they may disturb the proper functioning of the endocrine system [8]. They are included in the group of estrogenic compounds [9]. Epidemiological studies, run in multiple research centres all over the world, have pointed to a relationship between breast cancer and PCB concentration in the fatty tissue of women [10, 11]. The Environmental Protection Agency of the USA (US EPA) and the International Agency for Research on Cancer (IARC) have classified PCBs as carcinogenic substances [2].

In the human body, PCBs undergo bio-transformation to mono- and dihydroxyl compounds. During pyrolysis, they are transformed into polychlorinated dibenzofurans (PCDF) and polychlorinated dibenzodioxins (PCDD) characterized by extremely high toxic activity when used even in trace amounts and, next to PCBs, occur in natural environments and foodstuffs. They have also been found in human milk [12, 13].

The main route of polychlorinated biphenyl penetration into the human body is the gastrointestinal tract, where those compounds are brought with food. The highest PCB levels have been reported in food of animal origin, namely animal fats, fish and meat [14, 15, 16, 17, 18]. They have also been found in milk. A serious phenomenon is their presence in human milk, which is the only proper food for neonates. The occurrence of polychlorinated biphenyls in human milk has been reported world-wide, but in different concentrations depending on the country's region and year they were measured. Table 1 presents the levels of PCB determined in human milk from different countries in the last two decades.

PCBs have a proven detrimental impact on the human body, and children have been found to be especially sus-

ceptible [19, 20]. Hence, special attention should be paid to PCB presence in food designed for infants.

The objective of this study was to determine the content of polychlorinated biphenyls in human milk depending on the region and domicile of breast-feeding mothers as well as to compare the results obtained with PCB levels determined in UHT cow's milk infant formulas.

Material and Methods

Samples of human milk were collected at hospitals in Olsztyn, Białystok, Gdańsk and in the Śląsk region (Katowice, Zabrze, Tychy, Jaworzno) from January 1999 to February 2000. Milk samples were taken three, four, and five days after labour from women aged 17-43 years. Additional analyses were performed on UHT cow's milk with 3.2% of fat (Łaciate, Łowickie, Sielska Dolina, and Węgrów) and infant formulas (Nan and Bebiko – prepared according to instructions). In total, 174 samples of human milk, 16 samples of cow's milk, and 6 samples of infant formulas were analyzed.

To determine PCB content, fat was extracted from milk samples. The level of PCBs in the milk fat obtained was assayed with the method developed by the State Institute of Hygiene in Warsaw [21]. A chromatographic analysis was run by means of a PU 4600 Unicam apparatus with an electron capture detector (ECD) equipped in a glass column (2.1 m x 4 mm) filled with 1.5% SP 2250 + 1.95% SP 2401 on Supelco-port (100/120 mesh). Argon was used as the carrier gas supplied at a flow rate of 60 cm³/min. Separation temperatures were: 198°C for the column, 250°C for the detector and 225°C for the evaporator.

The effect of the analyzed factors on the values of the assayed properties was analyzed with the method of variance (Test F) for homogenous experiments. The standard

Table 2. PCB levels in human milk, UHT cow's milk and infant formulas (mg·kg⁻¹ of milk fat).

Σ PCB	Human milk n = 174	UHT cow's milk n = 16	Infant formulas n = 6
Min	0.004	0.008	0.009
Max	0.854	0.068	0.021
Average	0.218a	0.035b	0.013b
SEM	0.018	0.003	0.001

Explanation: a, b – means marked with different letter differ significantly at $p \leq 0.01$.

Table 3. PCB levels in human milk according to the region in Poland (mg·kg⁻¹ of milk fat).

Σ PCB	Olsztyn n = 33	Białystok n = 52	Gdańsk n = 30	Śląsk n = 59
Min	0.011	0.021	0.077	0.004
Max	0.852	0.732	0.854	0.842
Average	0.199a	0.201a	0.351b	0.172a
SEM	0.046	0.027	0.045	0.029

Explanation: a, b – means marked with different letter differ significantly at $p \leq 0.01$.

error of the mean (SEM) was also calculated. Homogeneous groups (not significantly different means) were determined with a q - Student - Newman - Keuls test [22].

Results and Discussion

Polychlorinated biphenyls were identified in all the samples examined.

Table 2 compiles the results of PCB determination in the experimental milk. The lowest concentration of polychlorinated biphenyls was found in infant formulas. However, a level of PCB several times higher was noted in cow's milk and more than 12 times higher levels in human milk. The level of polychlorinated biphenyls recorded in human milk differed significantly ($p=0.01$) from those determined in cow's milk and infant formulas.

The results obtained for the PCB level in human milk are comparable with those reported by other authors who also observed much higher levels of polychlorinated biphenyls in human milk compared to cow's milk and infant formulas [15, 16, 23].

Table 3 presents the results of PCB concentrations in the samples of milk collected from women living in different parts of Poland. Human milk specimens were collected in rural (Olsztyn, Białystok) and industrialized areas (Gdańsk, Śląsk). The lowest levels of PCBs were observed in milk obtained from inhabitants of Śląsk – 0.172 mg·kg⁻¹ of milk fat, on average. In the human milk of women living in Olsztyn, the average PCB content reached 0.199 mg·kg⁻¹ of milk fat. The average PCB content in the milk formulas from Białystok accounted for 0.201 mg·kg⁻¹ of milk fat. In the case of PCB contents recorded in human milk col-

lected in the area of Olsztyn, Białystok and Śląsk, no statistically significant differences were observed in PCB levels in milk in particular regions. In contrast, statistically significant differences ($p=0.01$) were noted in the case of PCB residues of human milk collected from Gdańsk, where the average PCB level was the highest compared to that reported for human milk from other regions. The level of PCBs in the milk of women living in Gdańsk was found to be 1.7-2 times higher than that found in human milk from other regions of the country. Hence, it may be suggested that the content of PCBs in human milk is determined by the area they live in.

In a study performed in the years 2000-01, the Σ PCB level in human milk in the region of Wielkopolska ranged from 0.027 to 0.332 mg (0.113 mg·kg⁻¹ of milk fat, on average), [24]. The average PCB content obtained in this study is nearly twice as high as the average content of polychlorinated biphenyls determined in the human milk of women living in the Wielkopolska region.

In Lubelskie Province, as well as in the former Krakowskie and Katowickie Provinces, the differences in PCB levels in human milk between particular regions reached from 0.310 mg·kg⁻¹ of milk fat in the Lubelskie Province to 0.500 mg·kg⁻¹ of milk fat in Katowickie Province [16].

Table 4 presents the PCB levels found in the human milk of women inhabiting either urbanized or rural areas. In the human milk of women originating from rural areas, the level of polychlorinated biphenyls was found to be 37% higher than that reported in the milk of women living in a city. The differences were not, however, statistically significant. Such differences were not reported by other authors [25].

Table 4. PCB levels in human milk depending on a women's location (mg·kg⁻¹ of milk fat).

Σ PCB	Urban area n = 141	Rural area n = 33
Min	0.004	0.030
Max	0.852	0.854
Average	0.203a	0.279a
SEM	0.019	0.046

Explanation: a – lack of significant differences

For several years, PCB levels in human milk has been observed to have decreased in many countries [26, 27]. That tendency pertains also to Poland, where the level of PCBs in human milk reached 0.490 mg·kg⁻¹ of lactic acid in 1980-81 and is now several times lower.

The above results for PCB levels in human milk show that the region may affect PCB content in human milk of the women inhabiting it. This may be due to the amount of these compounds introduced into the natural environment, depending on the industrialization degree of the region. The level of PCBs in human milk may also be influenced by other factors, including age and body weight of women, smoking, number of lactations, period of breast-feeding, etc. This factors will be discussed in further studies.

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