PCDD/PCDF in Chinese Teas

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1 ABSTRACT

Four samples of Chinese tea and infusions prepared from these teas have been analyzed for PCDD/PCDF. Whereas the concentrations in tea leaves from green tea and brick tea differed by a factor of 16, the concentrations of all infusions were within a factor of 2. The dioxin concentrations in green tea leaves can be explained through uptake of atmospheric PCDD/PCDF, the higher concentrations in the brick tea leaves are due to additional components such as soil particulates and perhaps fruit components. The Chinese habit of using brick tea for consumption in certain regions of China and the fact that an average Chinese person consumes more tea than normal Europeans or North Americans results in a higher intake of PCDD/PCDF from this pathway. Tea consumption can attribute to up to 10 % of the TDI recommended by WHO (only PCDD/PCDF considered, no PCB analyzed).

Key-words: polychlorinated dibenzo-*p*-dioxins, polychlorinated dibenzofurans, Chinese tea, tolerable daily intake

2 INTRODUCTION

Polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans (PCDD/PCDF) are high priority chemicals and presently under discussion for a global convention to be negotiated. The World Health Organization (WHO) has set a Tolerable Daily Intake of 1-4 pg WHO-TEQ/kg body weight and day for the intake of PCDD, PCDF and coplanar and mono-ortho substituted PCB combined. Exposure to PCDD/PCDF primarily occurs *via* food intake and especially *via* fatty foods such as dairy products, meat, eggs, and fish (van Leeuwen and Younes 1998). Nevertheless, special dietary habits or other consumption patterns such as tobacco smoking may pose an additional pathway which can significantly contribute to human exposure.

Normally, water-based drinks have a negligible share to the human exposure (Fürst 1999, EU 1999, King *et al.* 1999). The situation may be different for the Chinese population due to a) the special habit in some agricultural areas of China, in Mongolia or parts of Russia to consume so-called brick tea, 2) to make tea with several infusions of the same tea leaves, and 3) to consume more than three liters of tea daily. In this project, we analyzed tea leaves and infusions prepared from these leaves from different regions of China.

Besides the study of human exposure *via* tea, leaves from vegetation are biomonitors for chemicals like PCDD/PCDF. Thus, the results will also give an indication of the contamination in Chinese regions with these compounds.

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3 MATERIALS AND METHODS

Green teas and black leaves and infusions of these leaves have been analyzed in this project. Green tea is produced by picking young tea leaves, withering, steaming or pan firing, drying and grading (sifting) them. Afterwards, the tea is packaged and sold for consumption without fermentation. The pan firing over smoke is needed prevent fermentation of thetea leaves from fermenting by the natural enzyme activities. Brick tea is a black tea and of a much lower quality than green tea (or other quality black teas) as this tea is produced by picking old or rotten leaves and branches. To make brick tea, the tea is allowed to ferment for many hours before being either smoke fired, flame fired or steamed. Withering takes place as water evaporates and the natural process of fermentation takes place. Fermentation alters the chemical structure of thetea leaf. For sale, the tea is pressed into bricks (where the name comes from) (Chen 1992, Fung *et al.* 1999).

A total of four brands of tea products – two green teas and two brick teas - were purchased from different provinces of China: Green teas were produced on Lantau Island in Hong Kong (sample A) and in Lechang situated at northern Guangdong Province (sample B). The two brands of brick teas originated from Sichuan (sample C) and Hunan (sample D).

To prepare the infusions, 50 g of each tea has been boiled with tap water for 30 min and then was allowed to stand for 10 min. prior to decanting. 3-4 liters of the infusions were extracted for analysis. A subsample of 50 g of the green teas and brick teas were analyzed as received from the shop.
Clean-up and sample preparations of the tea leaves and the infusions were performed according to standard methods. Separation and determination of the 17 2,3,7,8-substituted PCDD/PCDF congeners were performed by HRGC/HRMS using a 60 m column (DB-Dioxin) and a high resolution mass spectrometer at a resolution of 6,000.

4 RESULTS

The results of the analysis are shown in Table 1 where in the third column the WHO-TEQs have been calculated by setting all concentrations below the analytical limit of quantification (LOQ) to zero whereas in the 4th column, the TEQs have been calculated by setting the concentrations of the congeners below the limit of quantification (LOI) at the LOD. The PCDD/PCDF concentrations in the green tea were 0.18 and 0.42 ng WHO-TEQ/kg (0.15 and 0.40 ng WHO-TEQ/kg for ND=0) whereas the concentrations in the brick tea samples were higher 1.0 and 2.6 ng WHO-TEQ/kg (all congeners could be quantified) and thus, up to 10-fold higher than the green tea samples. The tea infusions had concentrations between 1.4 and 2.4 pg WHO-TEQ/L (0.7-1.7 pg WHO-TEQ/L) with a tendency towards lower levels in green tea and higher levels in brick tea. However, the differences between these two categories were not so large than was for the tea leaves.

Table 1: PCDD/PCDF concentrations in tea leaves (samples A-D) and in prepared teas (T-A through T-D)

Sample	Unit	ND=0	ND=LOQ
A	ng WHO-TEQ/kg	0.154	0.177
B	ng WHO-TEQ/kg	0.400	0.420
C	ng WHO-TEQ/kg	1.009	1.009
D	ng WHO-TEQ/kg	2.584	2.584
T-A	pg WHO-TEQ/L	0.675	1.374
T-B	pg WHO-TEQ/L	1.028	1.727
T-C	pg WHO-TEQ/L	0.933	1.602
T-D	pg WHO-TEQ/L	1.710	2.409

In Table 2, the daily intake through consumption of tea is displayed. As can be seen, the total daily intake through consumption of 3 L of tea infusions is between 4.12 and 7.23 pg WHO-TEQ per person and day (2.03 and 5.13 pg WHO-TEQ/d, ND=0). For a 70 kg person, the intake of green tea will result in a share of 6 or 7.4 % of the WHO guideline value (targeted TDI of 1 pg TEQ/kg bw·d). Drinking 3 L of brick per day will result in a share of 7 % or 10 % of the TDI. Assuming ND=0, the shares will be slightly lower. It should be noted that these percentages only address PCDD and PCDF and do not take into account the coplanar and *mono-ortho*-substituted PCB.

Table 2: Daily intake through consumption of Chinese tea in pg WHO-TEQ per person

	Daily Intake		% of TDI Target	
	ND=0	ND=LOQ	ND=0	ND=LOQ
T-A	2.03	4.12	2.9%	5.9%
T-B	3.08	5.18	4.4%	7.4%
T-C	2.80	4.81	4.0%	6.9%
T-D	5.13	7.23	7.3%	10.3%

5 Discussion

Within this project, only a very limited number of samples could be analyzed. The results showed that there is a background contamination with PCDD/PCDF. Based on knowledge that soil contamination with PCDD/PCDF does not transfer into plants, it can be assumed that the green tea leaves obtained all its PCDD/PCDF through atmospheric deposition. Concentrations of 0.18 and 0.42 pg TEQ/kg d.m. are comparable to concentrations found in Welsh ryegrass in Germany and other European countries (EU 1999, Fiedler *et al.* 1999). The higher concentrations in the brick tea samples are due to contamination with fine soil particles and other constituents with possibly longer exposure times than the young green tea leaves.

The results of the tea infusions show that there is some transfer of the PCDD/PCDF contamination of the leaves into the aqueous phase. If this mobilization is facilitated by the long treatment with hot water or through the presence of other organic compounds such as tannins or phenolic constituents of the tea cannot be determined through the study design used in this project. It should be noted that the range of dioxins and furan concentrations in the tea infusions is much smaller than the range determined for the tea leaves.

Based on present knowledge about dioxin and furan exposure pathways (Fürst 1999), it can be concluded that the Chinese tradition to drink three liters of tea (or more) per day and the procedure to prepare infusions results in a higher share of the daily intake of PCDD/PCDF than calculated for the general population in Europe or North America.

6 ACKNOWLEDGMENT

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Steps to Solving the Global POPs Problem

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ABSTRACT

Over the course of the past few years, a number of actions have been undertaken to address the global problem of persistent organic pollutants (POPs). In 1997, the United Nations Environment Programme (UNEP) was requested by governments to convene negotiations of a global legally binding instrument to reduce and/or eliminate releases of POPs into the environment. In addition, UNEP and others were called upon to undertake a number of immediate actions to rapidly respond to the global POPs problem and reduce exposures and risks in the near term. The combination of requested actions, and the urgency of the request, has resulted in rapid progress on the future POPs treaty as well as a number of interesting and innovative arrangements to address the POPs problem, particularly in developing countries and countries with economies in transition.

INTRODUCTION

Over the past 30 or so years, a number of countries have taken steps to address national risks from persistent organic pollutants. These have included imposing bans or severe restrictions on organochlorine pesticides, and regulating polychlorinated benzenes and in many cases taking them out of use and disposing of them. A relatively more recent development is acknowledgement of the risks of dioxins and furans, and taking steps to quantify releases and address the sources of environmental release.

As the extent of the transboundary nature of the POPs problem became better understood, governments began the steps of developing bilateral agreements as well as regional treaties to control the continued spread of pollution from POPs. These include such measures as the Oslo-Paris Convention (North-East Atlantic), the Barcelona Resolution (Mediterranean), the Canada/USA Great Lakes Agreement, the Helsinki Convention (Baltic) and the UNECE POPs Protocol of the Convention on Long Range Transboundary Air Pollution.

Eventually it was recognized that, although these many national actions and regional agreements were of great benefit, particularly as concerned local exposures, POPs represented a truly global problem that could not be addressed without a global approach. At the 18th session of UNEP's Governing Council in 1995, governments called for an assessment of the global POPs problem to be developed under the Inter-Organization Programme for Chemical Safety[1] (IOMC) and the International Programme on Chemical Safety (IPCS). The Intergovernmental Forum on Chemical Safety (IFCS) was requested to consider the analysis developed under the IOMC and make recommendations for action to UNEP for consideration by the Governing Council at its 19th session in 1997. On the basis of the recommendations made by IFCS, the decision was taken by

[1] A programme to promote strengthened coordination among the major intergovernmental organisations involved in Chemical safety (UNEP, ILO, FAO, WHO, UNIDO, UNITAR, and OECD).