Transfer Pathways of Polychlorinated Dibenzoparadioxins and Polychlorinated Dibenzofurans to Fruits

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Introduction

Although PCDD/PCDF contaminated animal products are the predominant source of human body burden[1,2,3] in areas with high environmental concentration of PCDD/PCDF the consumption of vegetables and fruit can become a major contribution[4].

In the city of Rheinfelden (Germany), the highly contaminated area is close to the town centre and used for backyard gardening. The main contamination, dumping and landfilling of chlorine-alkaline-electrolysis residues, occured between 1900 and 1921. For decades this land was used for private and commercial fruit and vegetable production.

In 1989 high soil concentrations of PCDD/PCDF were discovered and possible pathways of these compounds to fruits and vegetables became a major issue.

Objectives

The objective of this study was to estimate the relative importance of the different pathways on fruit contamination. As typical fruits grown in this area pears and apples were used in our study.

A more detailed knowledge about the contamination pathways is indispensable for determination of critical soil levels and also for recommendations concerning cultivation, harvest and post-harvest processing.

Shoots can be contaminated via the following pathways:

1. Root uptake and transport to the shoot
2. Contamination of shoots by soil particles and atmospheric deposition
3. Uptake from the gas phase

Experimental

In order to estimate the root uptake (pathway 1) the pear cultivar "Gräfin von Paris" growing on two differenty contaminated plots was selected. The contamination level of the soil differed not only in I-TEq (Table 1) but also in the distribution pattern of the congenere groups.

To evaluate the influence of the fruit surface properties (e.g. cuticular and stomatal conductivity) for pathway 2 and 3 the trial comprised two pear trees and one apple tree (cv. "Brettacher"). For evaluation of a contribution of soil and dust contamination (pathway 2) after pollination some of the flowers were covered with vellum-paper bags until harvest.

The distance between the three trees is less than 100 m so that similar PCDD/PCDF concentrations in the atmosphere are assumed. For this reason differences in uptake from the gas phase (pathway 3) are considered as negligible for potential differences in plant contaminations.

For risk assessment also the impact of post-harvest treatments (washing, peeling) on the PCDD/PCDF contents were investigated. The soil and fruit analyses were performed in "ERGO" laboratories, Hamburg.

The experimental design is summarized in Table 1.

Table 1: Study site "Rheinfelden" with two pear trees and one apple tree on soils with different PCDD/PCDF contamination levels in topsoil and subsoil.

	PCDD/PCDF in soil, values in ng I-TEq/kg		
Soil depth	pear 1	pear 2	apple
0 - 30 cm	2970	448	7480
30 - 70 cm	14530	48	2950
Treatment	fruit parts		
unprocessed	whole	-	-
washed	peel, pulp	whole	peel pulp
wrapped	whole	-	-

Results

The PCDD/PCDF concentrations in whole fruits ranged from 1-4 ng/kg FW for total PCDD/PCDF and from 8-50 pg/kg FW for I-TEq. PCDD/PCDF concentrations in the peel were 4-8 times higher than in the pulp. Wrapped fruits showed lower PCDD/PCDF concentrations than unwrapped fruits. Washing of the fruits had no effect on PCDD/PCDF concentrations (Tab. 2).

Table 2: PCDD/PCDF in various fruit samples
Total PCDD/PCDF in ng/kg FW (I-TEq in pg/kg FW)

		pear 1 *	pear 2	apple
unprocessed	whole fruit	3.48 (48)	-	-
		1.80 (20)	-	-
washed	whole fruit	2.33 (27)	1.59 (25)	1.45 (14)
		2.66 (45)	-	-
	peel	7.96 (105)	-	3.79 (46)
		7.33 (142)	-	-
	pulp	1.00 (8)	-	0.98 (8)
		1.52 (21)	-	-
wrapped	whole fruit	1.18 (11)	-	-
		1.35 (17)	-	-

* Two samples from the same tree

Soil samples of each of the three trial sites showed a distinct homologue distribution pattern. It appears that the distribution patterns of fruit samples had no similarity with the respective soil patterns (Fig.1 & 2). In all fruit samples OCDD and TCDF were the predominant homologue groups.

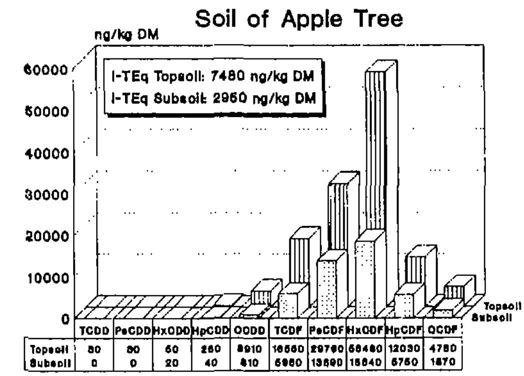

Figure 1

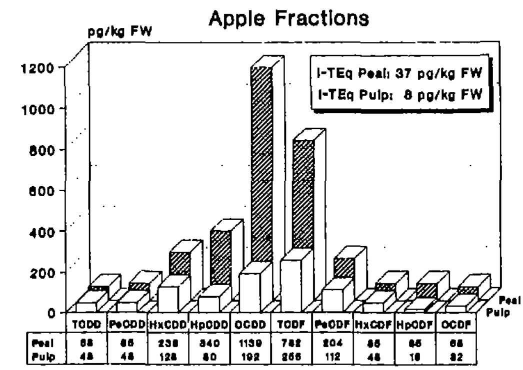

Figure 2

Fig. 1 & 2: Homologe patterns of PCDD/PCDF congeneres in soil (Fig.1) and apple (Fig.2)

Discussion:

The results of the various soil and fruit samples show no correlation between PCDD/PCDF concentrations in soil and fruit. Furthermore higher levels of PCDD/PCDF in the peel than in the pulp indicate that the contamination pathway air-plant is of far greater importance than the pathway soil-plant. It is known from the literature[5], that in samples of wet and dry deposition OCDD is the main component; in immission samples OCDD, TCDF and PCDF predominate. This is in good agreement with the homologue patterns of the fruits in our study (Fig. 2), where OCDD and TCDF are the main components. We thus consider adsorption from gas phase and dust onto the peel, and a subsequent slow transfer via diffusion into the pulp as responsible factor for fruit contamination whereas root-uptake and transport to the shoot is negligible.

Highest PCDD/PCDF concentrations were found in the peel; therefore, peeling is a feasible precaution to reduce the uptake of these substances. In a study on spruce needles[6] it has been shown that the lipophilic plant surfaces can function as effective sink for air-borne lipophilic substances. Therefore it is not surprising that washing of the fruit had no effect on PCDD/PCDF concentrations in the peel.

Literature

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