Risiken erkennen – Gesundheit schützen

Impact of revised toxicity equivalency factors (TEFs) on the toxic equivalents (TEQs) of the World Health Organisation

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The term “dioxins” used colloquially not only encompasses polychlorinated dibenzo-p-dioxins but also dibenzofurans. Both have similar chemical, physical and toxic properties and occur as mixtures. In the two groups – “dioxins” and dioxin-like, polychlorinated biphenyls (dl-PCBs) – there are individual substances with differing degrees of toxicity, called congeners. In order to express the differing degrees of toxicity of these congeners in the mixtures, the World Health Organisation (WHO) introduced the system of toxic equivalents. The toxicity of individual substances is compared with that of the most toxic congener, 2,3,7,8-TCDD, better known as “Seveso dioxin”. The toxicity equivalency factor indicates the respective difference in toxicity. By multiplying them by the toxicity equivalency factors (TEFs), the amounts of the individual congeners are initially calculated as toxic equivalents. They are then added together to give the total concentration of toxic equivalents (TEQs). WHO determined the toxicity equivalency factors in 1998. Within the framework of a routine review it reassessed these factors and published revised TEFs in 2005 although the toxicological data situation had not changed. For around half of the congeners the TEFs have remained the same, for the others they are mostly lower than the previous values.

The Federal Institute for Risk Assessment (BfR) has now examined whether and, if so, how these “new” TEFs affect the calculation of the total sum of toxic equivalents. To this end, the Institute used data material from the national dioxin database and did some comparative calculations. The result: the revised toxicity equivalency factors lead to WHO-TEQ concentrations which are between 10 and 20 percent lower for foods and by as much as 25 percent lower for breast milk. Based on the “new” TEFs consumers could ingest far more dioxins and dioxin-like PCBs from food until, in pure arithmetical terms, they reach the acceptable daily intake of 1-4 picogram WHO-TEQ per kg and bodyweight (pg WHO-TEQ kg bw) established by WHO.

BfR examined the impact of the revised TEFs on 1,156 food samples and 604 breast milk samples between 2000 and 2005 and 1999 and 2005 respectively. It is of the opinion that they could, in fact, lead to a lower level of protection for consumers against dioxins and dioxin-like PCBs in food. The following calculations illustrate this point. In its evaluation WHO lowered the TEF from 0.5 to 0.3 for the furan 2,3,4,7,8-PeCDF, which is found in relatively high concentrations in foods. The consequence is that the TEQ values are lower although the same dioxin concentration is still contained in foods as before. The same holds for breast milk. It also has a relatively high share of PCB 156 and its lower TEF has a clear impact on the TEQ value. Taking the same level of exposure, it is lower when calculated with the revised TEF from 2005 than in the comparative calculation using the TEF from 1998. These comparisons underpin the results of the BfR Expert Opinion from 4 September 2006 [1], in which the Institute drew attention for the first time to the impact of the new WHO-TEFs. As exposure estimates indicate that a considerable proportion of the population has an elevated dioxin intake BfR felt there was a risk that this could lead to a lower level of consumer health protection and recommended and that the TEFs should only be amended when new, relevant toxicological findings became available. Furthermore, the taking over of the new TEFs would impede observations of the time course of exposure over the years and, by extension, of the trend.

The present study examined the effect of the re-evaluated and modified WHO-TEFs on WHO-TEQs. **It** was conducted by the Federal Institute for Risk Assessment (BfR) and aimed

at calculating the WHO-PCDD/F-TEQ, WHO-PCB-TEQ and WHO-PCDD/F-PCB-TEQ concentrations. The study was based on TEFs from 1998 and 2005, and on data compiled in the German DIOXIN database (“*Datenbank DIOXINE”).*

The DIOXIN database comprises 1156 food sample entries collected between 2000 and 2005, and 604 breast milk samples from the period 1999.2005. It can therefore be considered as an up-to-date and representative basis for calculating the TEQs.

The results are presented as statistical key data and are illustrated by graphics. Table 1 shows the number of samples of individual food groups and breast milk. Since the analysis of dioxin-like PCBs (dl-PCBs) started quite lately, database on WHO-PCB-TEQ and WHO-PCDD/F-PCB-TEQ is little: 114 samples out of a total of 1156 food samples and 214 out of a total of 604 breast milk samples were tested for both dl-PCBs and PCDDs/Fs. The number of food and breast milk samples is not equally distributed within the reported period. Samples containing PCDD/F or PCB concentrations higher than average levels were not excluded from our data analysis because of the broader basis for data interpretation they might offer.

Although the high contamination levels figuring in the following tables are not representative for these foods, they are still included, because they can mirror potential contaminations in food. However, the median value characterises the TEQ levels in breast milk and foods adequately.

Table 1: Number of Samples

Kind of Samples	PCDD/F-TEQ	PCB-TEQ
Cow’s Milk	501	41
Egg	364	53
Fish	89	
Meat	160	
Vegetables	42	20
Total of Foods	1156	114
Breast Milk	604	214

Table 2 reveals a decrease of WHO-TEQ values in all kinds of foods and breast milk particularly for WHO-PCDD/F-TEQ, WHO-PCB-TEQ and WHO-PCDD/F-PCB-TEQ when TEFs of 2005 are applied. The values listed in Table 2 are mean values. Further statistical parameters such as minimum, maximum and percentiles can be found in Table 3 to 9.

Table 2: Reduction of TEQ values in foods and breast milk based on WHO-TEF 2005 (mean value, in % relating to TEQ calculated with WHO-TEF-1998)

Kind of Sample	WHO-PCDD/F-TEQ	WHO-PCB-TEQ	WHO-PCDD/F-PCB- TEQ
Cow’s Milk	17.4	12.0	13.2
Egg	10.8	22.7	15.9
Fish			
Herring	21.1		
Salmon, Salmon-like	14.6		
Eel	15.0		
Meat			
Beef	18.1		
Pork	8.5		
Chicken	11.0		
Vegetables	14.7	20.5	16.9
Breast Milk	15.5	34.1	24.5

In summary, WHO-TEQ values found in individual foods decreased between 10 % and 20 % and even more in breast milk samples. The small differences found in special foods are not ambiguous, since the evaluation was based on samples not selected according to uniform statistical aspects. In great part the decrease of WHO-PCDD/F-TEQ is due to the relatively high concentrations of 2,3,4,7,8-PeCDF and a decline in TEF from 0.5 to 0.3. Modified TEFs for other PCDD/F congeners do not significantly alter the WHO-PCDD/F-TEQ values because congener concentrations are much lower or/and TEFs are only little. Yet, some of the samples do not correspond to the usual congeneric pattern as very high concentrations of OCDD have been detected in those samples. A reason might be the contamination of animal feed with PCP or PCDDs (kaolinitic clay). The importance of 2,3,4,7,8-PeCDF declines in WHO-PCDD/F-TEQ while OCDD is dominating (Tab. 4 and 6). When TEFs of 2005 are used the share of PCDDs contributing to WHO-PCDD/F-TEQ is higher whereas PCDFs contribute lower (Fig. 2, 5, 7-9, 11-13, 15).

WHO-PCDD/F-TEQ and WHO-PCB-TEQ decline similarly with the application of TEF 2005, even though the TEFs of 10 out of 12 dl-PCBs decreased approximately by an order of magnitude. This is due to the fact that the WHO-TEF of PCB 126, which has a remarkable share in the WHO-PCB-TEQ, is not changed (Fig. 3). Although the TEFs of mono-ortho-PCBs are significantly changed, their relevance for WHO-TEQ calculations is almost nil because of low TEF values. This is not true for breast milk. In breast milk samples PCB 156 is detected at a relatively high concentration. As the TEF decreases to a very low level, the WHO-PCB-TEQ and WHO-PCDD/F-PCB-TEQ values decrease equally (at a higher degree, Fig. 3 and 16).

(Cow's) Milk

Figure 1: WHO-TEQ-concentrations (ng/kg fat) in milk calculated with WHO-TEFs 1998 and WHO-TEFs 2005

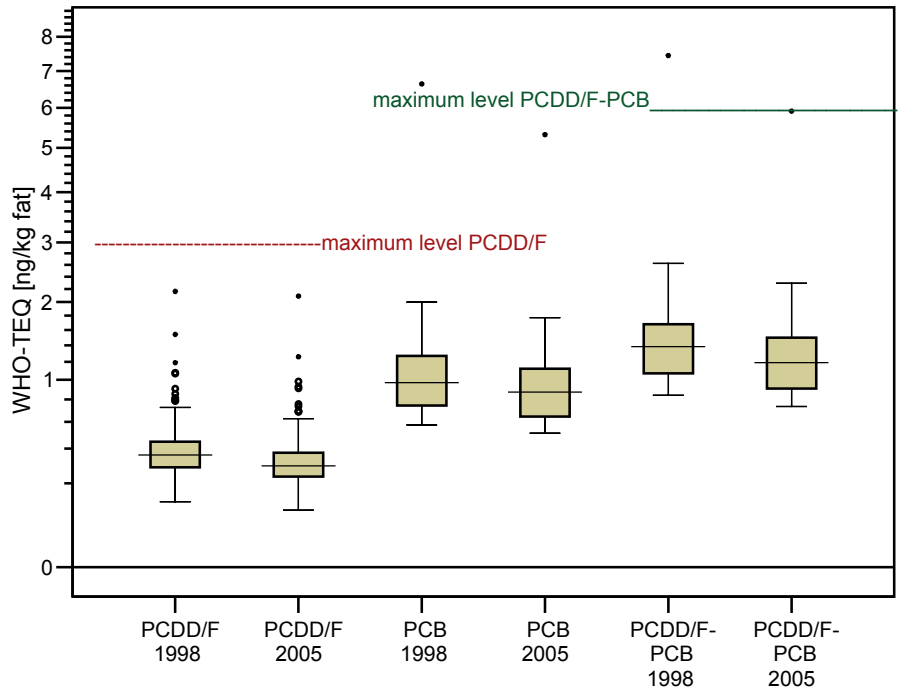


Table 3: Decrease [%] of WHO-TEQ concentrations in cow's milk by implementing new TEFs (2005) in comparison with WHO-TEFs 1998

		PCDD/F [%]	PCB [%]	PCDD/F-PCB [%]
Mean		17.4	12.0	13.2
Minimum		2.9	1.7	6.6
Maximum		26.2	22.5	21.8
Percentile	5	8.3	4.1	7.1
	25	14.8	9.6	11.5
	50	18.2	11.7	12.9
	75	20.4	13.8	14.6
	95	24.2	19.9	20.4
Number of samples		501	41	41

Figure 2: Percentage of PCDD/F-congeners in WHO-PCDD/F-TEQ in cow's milk

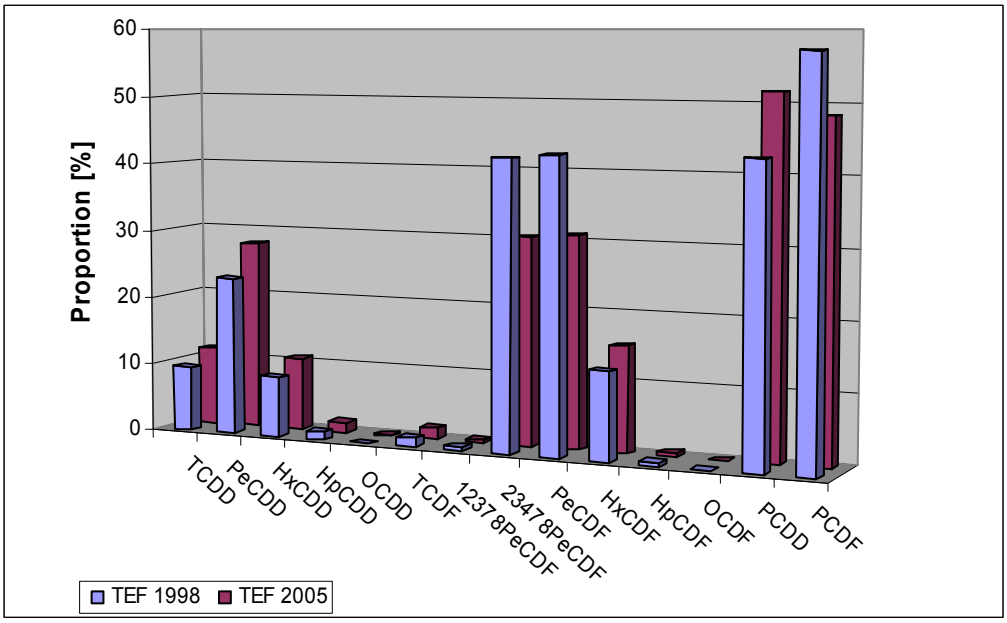
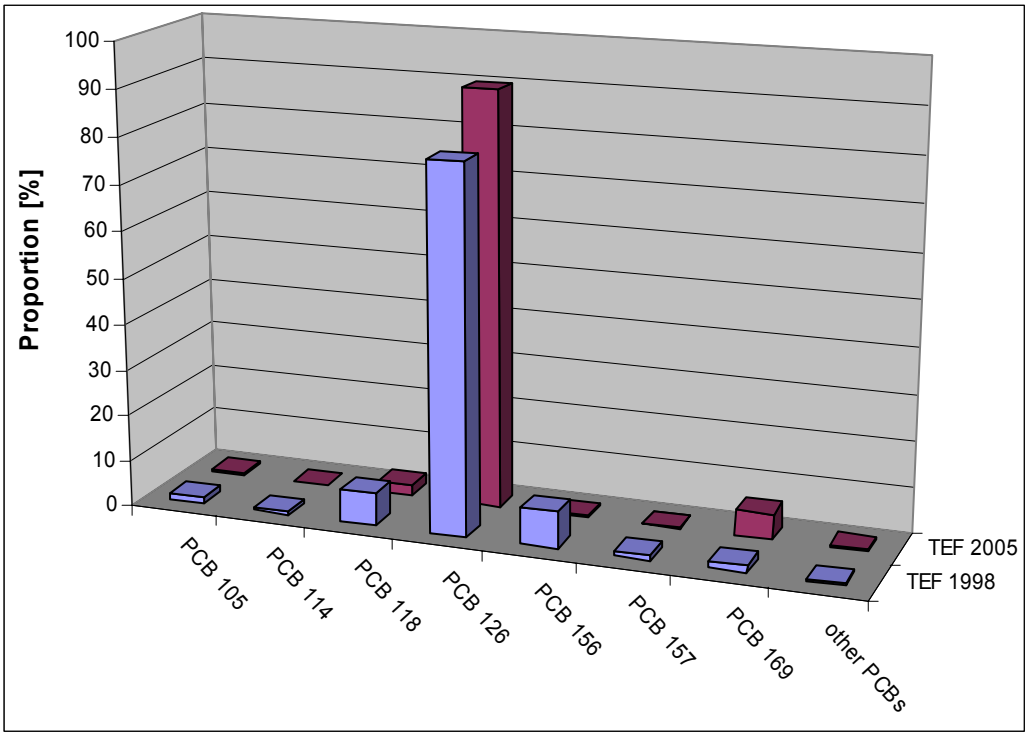


Figure 3: Percentage of PCB-congeners in WHO-PCB-TEQ in cow's milk



Egg

Figure 4: WHO-TEQ concentrations in egg calculated with WHO-TEFs 1998 and WHO-TEFs 2005

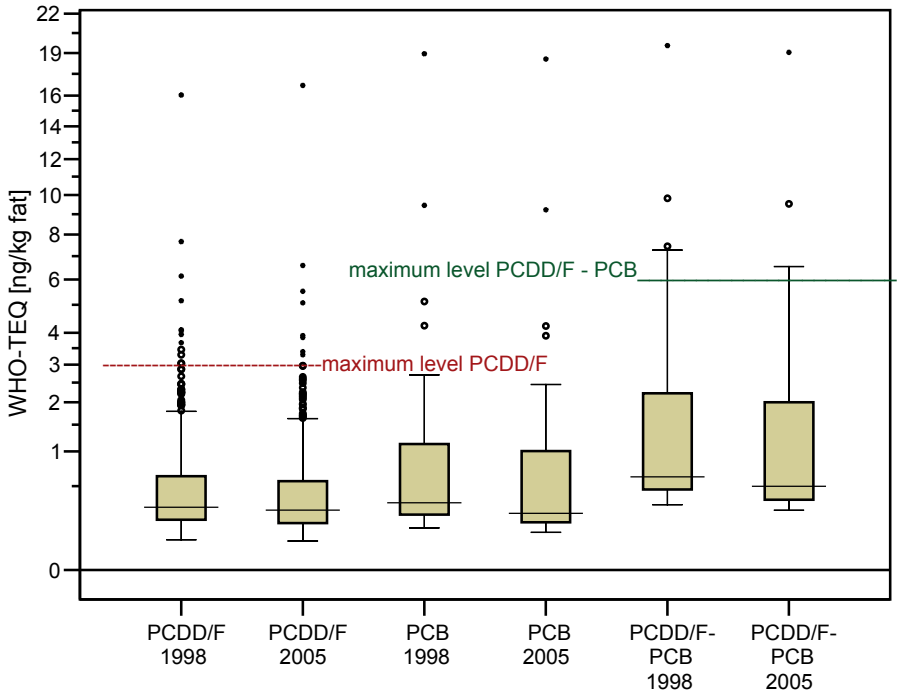
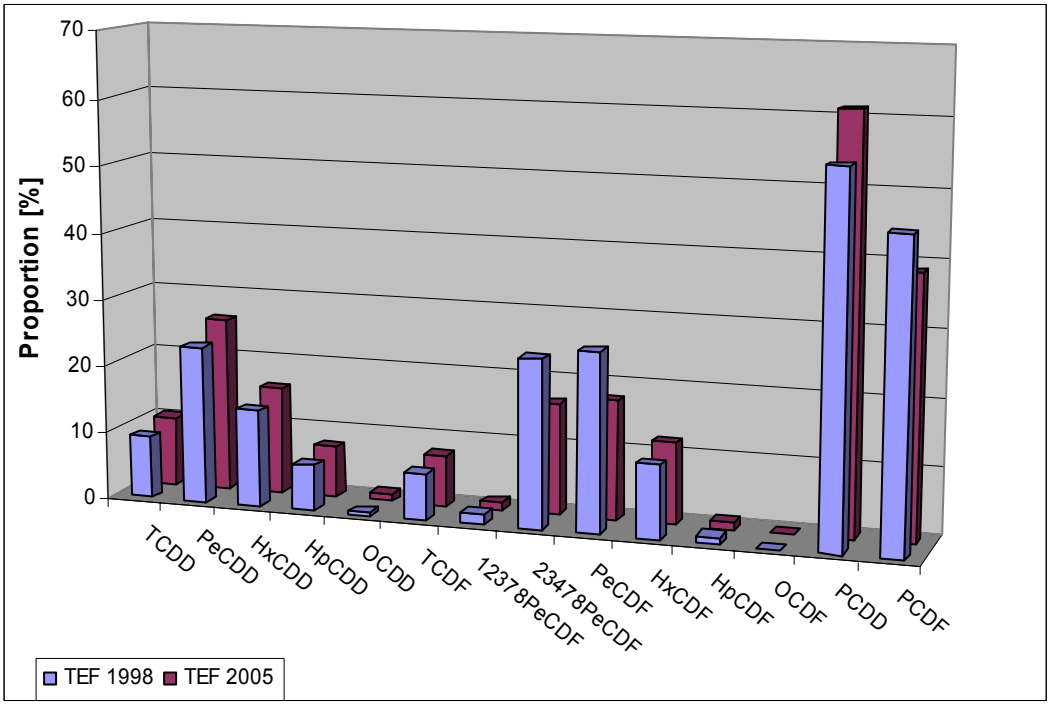


Table 4: Decrease [%] of WHO-TEQ concentration in egg by implementing new WHO-TEFs (2005) in comparison with WHO-TEFs 1998

		PCDD/F [%]	PCB [%]	PCDD/F-PCB [%]
Mean		10.8	22.7	15.9
Minimum		-15.8*	2.0	2.5
Maximum		21.4	46.6	32.3
Percentile	5	3.3	5.8	2.8
	25	8.3	14.6	11.6
	50	10.9	22.2	16.3
	75	13.6	29.5	19.2
	95	17.6	44.1	27.6
Number of samples		364	53	53

* TEQ calculated with TEF 1998 is lower than calculated with TEF 2005

Figure 5: Percentage of congeners in WHO-PCDD/F-TEQ in egg



Fish

Figure 6: WHO-TEQ concentrations in different kind of fish calculated with WHO-TEFs 1998 and WHO-TEFs 2005

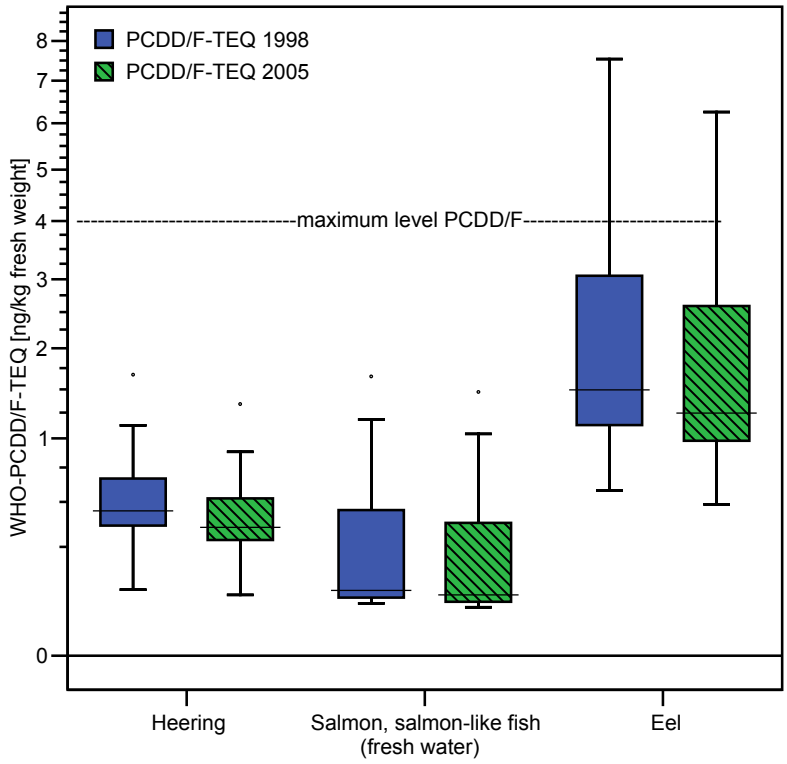


Table 5: Decrease [%] of WHO-TEQ concentrations in different kinds of fish by implementing new WHO-TEFs (2005) in comparison with WHO-TEFs 1998

		PCDD/F [%]		
		Herring	Salmon. salmon-like fish (freshwater)	Eel
Mean		21.1	14.6	15.0
Minimum		15.6	10.7	10.2
Maximum		25.9	19.6	24.2
Percentile	5	16.1	10.8	10.6
	25	20.2	12.4	13.1
	50	21.2	13.9	15.1
	75	22.1	16.4	16.3
	95	24.0	19.6	22.1
Number of samples		40	24	25

Figure 7: Percentage of congeners in WHO-PCDD/F-TEQ in herring

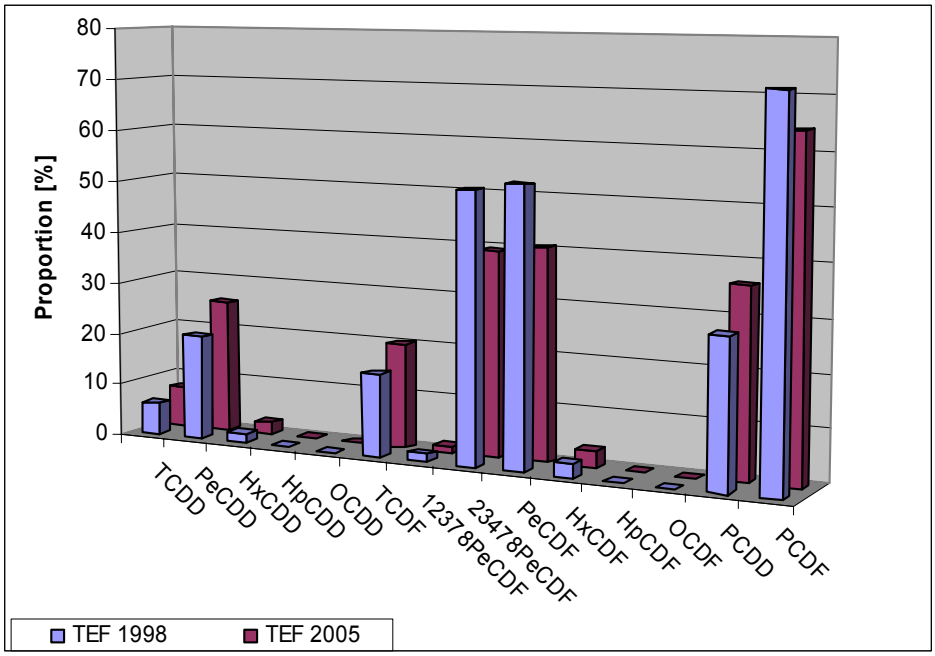


Figure 8: Percentage of congeners in WHO-PCDD/F-TEQ in salmon and salmon-like fish (freshwater)

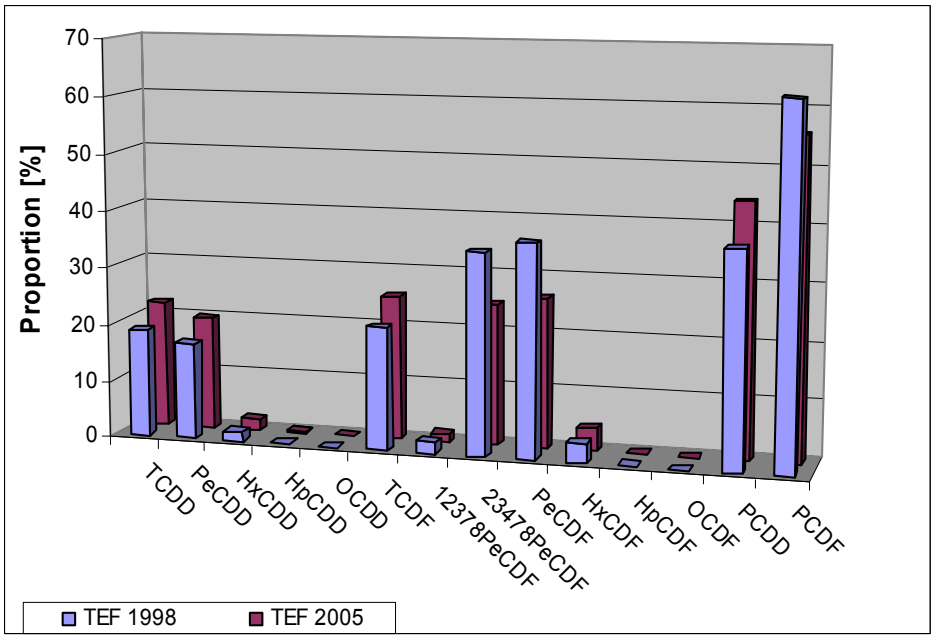
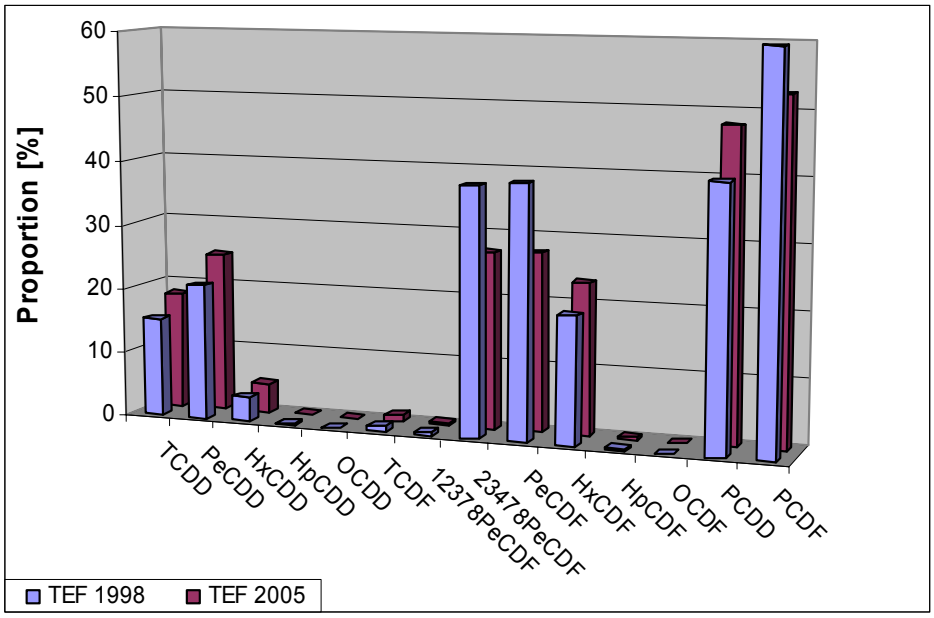


Figure 9: Percentage of congeners in WHO-PCDD/F-TEQ in eel



Meat

Figure 10: WHO-PCDD/F-TEQ concentrations in different kinds of meat calculated with WHO-TEFs 1998 and WHO-TEFs 2005

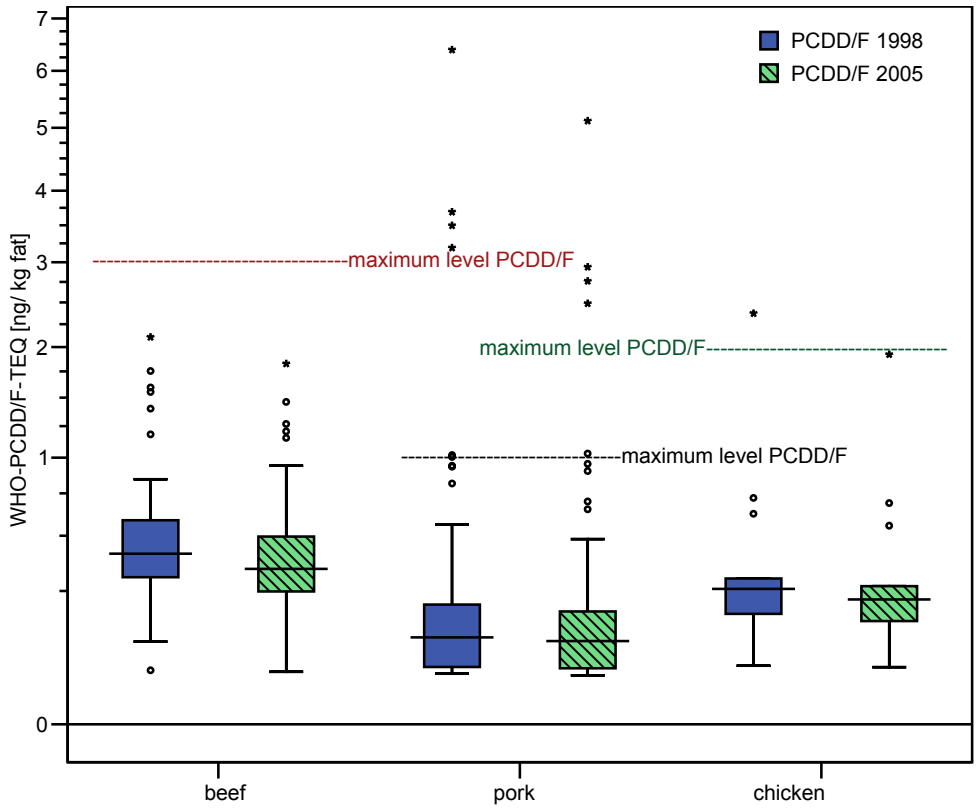


Table 6: Decrease [%] of WHO-PCDD/F-TEQ concentrations in meat from different kind of animals by implementing of new WHO-TEFs (2005) in comparison with WHO-TEFs 1998

		PCDD/F [%]		
		Beef	Pork	Chicken
Mean		18.1	8.5	11.0
Minimum		5.3	-1.7 *	4.4
Maximum		30.9	25.2	19.0
Percentile	5	11.3	0.8	4.4
	25	15.9	4.6	8.8
	50	17.9	5.6	10.9
	75	20.5	11.2	13.9
	95	25.0	22.1	(17.7)**
Number of samples		68	78	14

* PCDD/F-TEQ calculated with TEF 1998 lower then calculated with TEF 2005
** the 90th percentile has been given here, since due to the low number of samples a value for 95th percentile is lacking

Figure 11: Percentage of congeners in WHO-PCDD/F-TEQ in beef

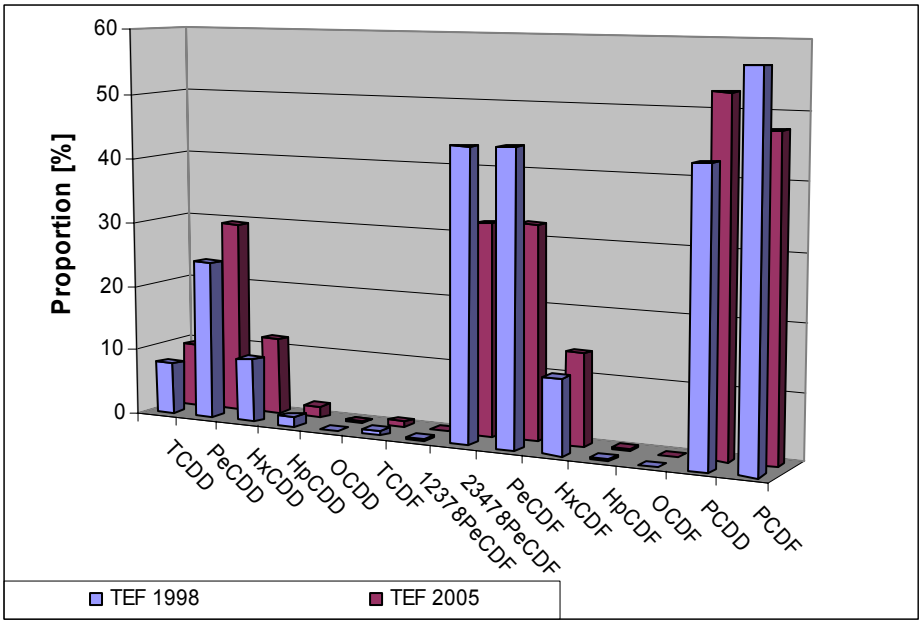


Figure 12: Percentage of congeners in WHO-PCDD/F-TEQ in pork

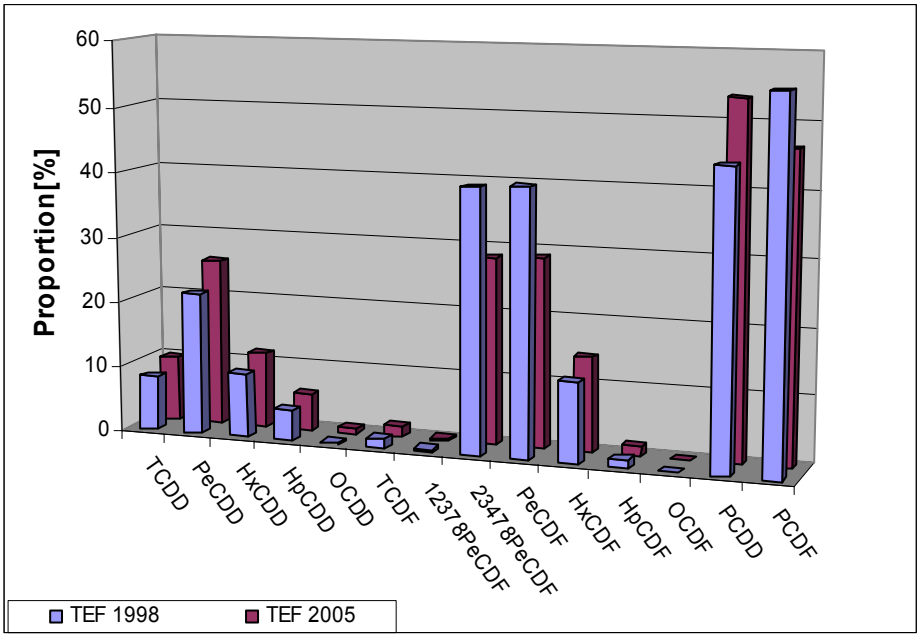
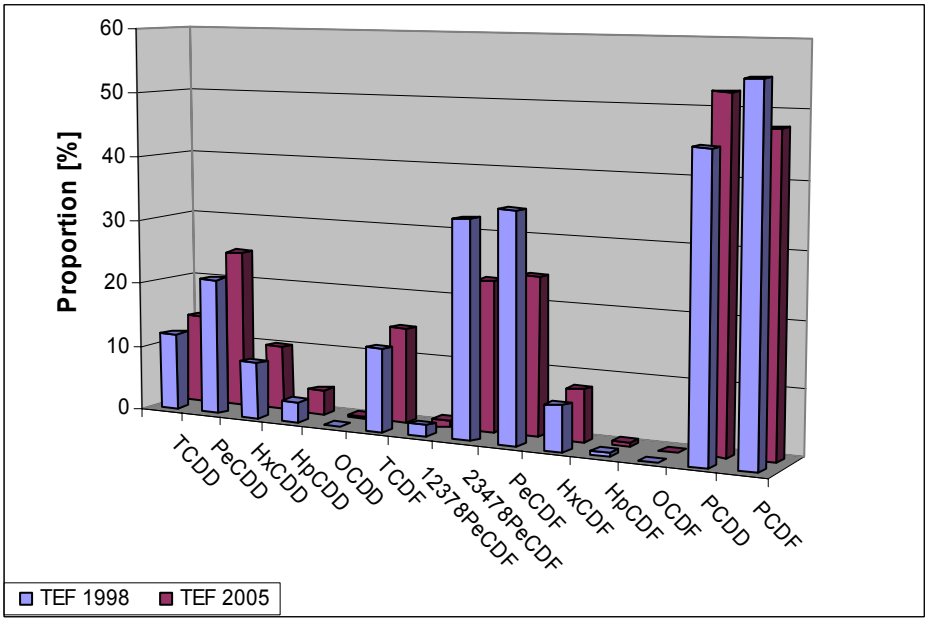


Figure 13: Percentage of congeners in WHO-PCDD/F-TEQ in chicken



Vegetables

Table 7: WH0-TEQ-concentrations [ng/kg fresh weight] calculated with TEFs 1998 and TEFs 2005

	PCDD/F 1998 [ng/kg fw]	PCDD/F 2005 [ng/kg fw]	PCB 1998 [ng/kg fw]	PCB 2005 [ng/kg fw]	PCDD/F-PCB 1998 [ng/kg fw]	PCDD/F-PCB 2005 [ng/kg fw]
zucchini						
Number of samples	16		10		10	
Mean	0.017	0.014	0.009	0.007	0.028	0.023
Median	0.010	0.008	0.005	0.005	0.019	0.015
Minimum	0.002	0.002	0.001	0.001	0.004	0.003
Maximum	0.055	0.048	0.040	0.028	0.096	0.074
carrot						
Number of samples	10		10		10	
Mean	0.004	0.004	0.002	0.002	0.006	0.005
Median	0.004	0.003	0.002	0.002	0.007	0.006
Minimum	0.002	0.002	0.001	0.001	0.004	0.003
Maximum	0.009	0.007	0.004	0.003	0.011	0.010
kale						
Number of samples	16					
Mean	0.086	0.074				
Median	0.070	0.061				
Minimum	0.043	0.039				
Maximum	0.285	0.238				

Table 8: Decrease [%] of WHO-TEQ concentration in zucchini, carrot and kale by implementing new WHO-TEFs (2005) in comparison with WHO-TEFs 1998

	zucchini			**carrot**			**kale**
	PCDD/F [%]	PCB [%]	PCDD/F-PCB [%]	PCDD/F [%]	PCB [%]	PCDD/F-PCB [%]	PCDD/F [%]
Number of samples	16	10	10	10	10	10	16
Mean	15.8	22.0	17.6	14.6	19.0	16.2	13.7
Median	16.0	24.9	16.9	14.7	12.8	15.9	14.0
Minimum	8.3	1.2	13.5	9.8	8.4	10.7	9.9
Maximum	24.2	30.8	23.1	19.5	36.6	23.0	17.8

Breast milk

Figure 14: Comparison of WHO-TEQ-concentrations in breast milk calculated with WHO-TEFs 1998 and WHO-TEFs 2005

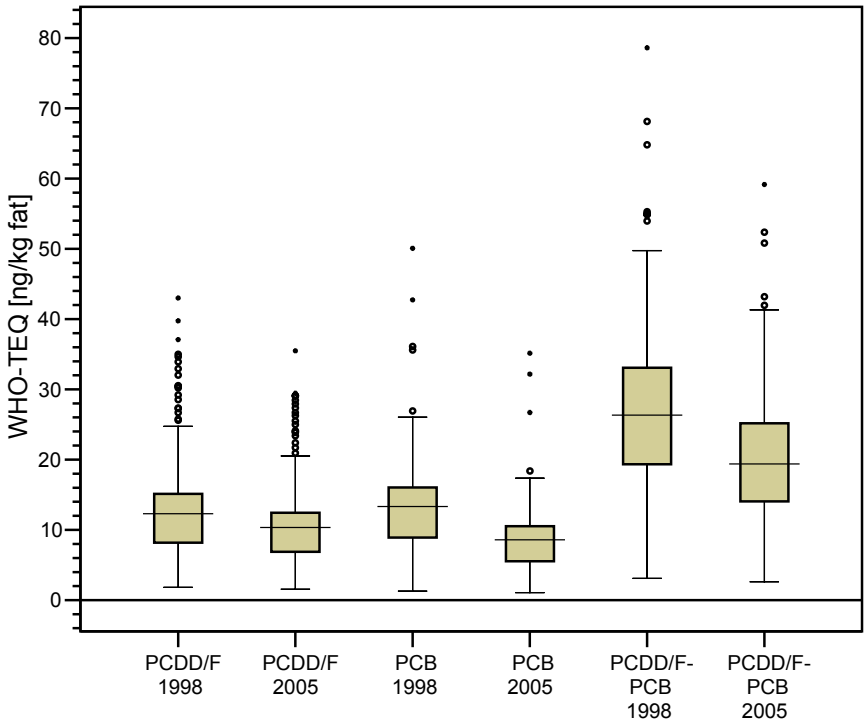


Table 9: Decrease [%] of WHO-TEQ concentrations in breast milk by implementing new WHO-TEFs (2005) in comparison with WHO-TEFs 1998

		PCDD/F [%]	PCB [%]	PCDD/F-PCB [%]
Mean		16.5	34.1	24.5
Minimum		9.2	10.7	13.1
Maximum		30.8	54.1	34.2
Percentile	5	13.6	22.2	18.7
	25	15.0	29.8	22.1
	50	16.1	34.5	25.1
	75	17.7	37.6	26.9
	95	20.8	45.6	29.5
Number of samples		604	214	214

Figure 15: Percentage of congeners in WHO-PCDD/F-TEQ in breast milk

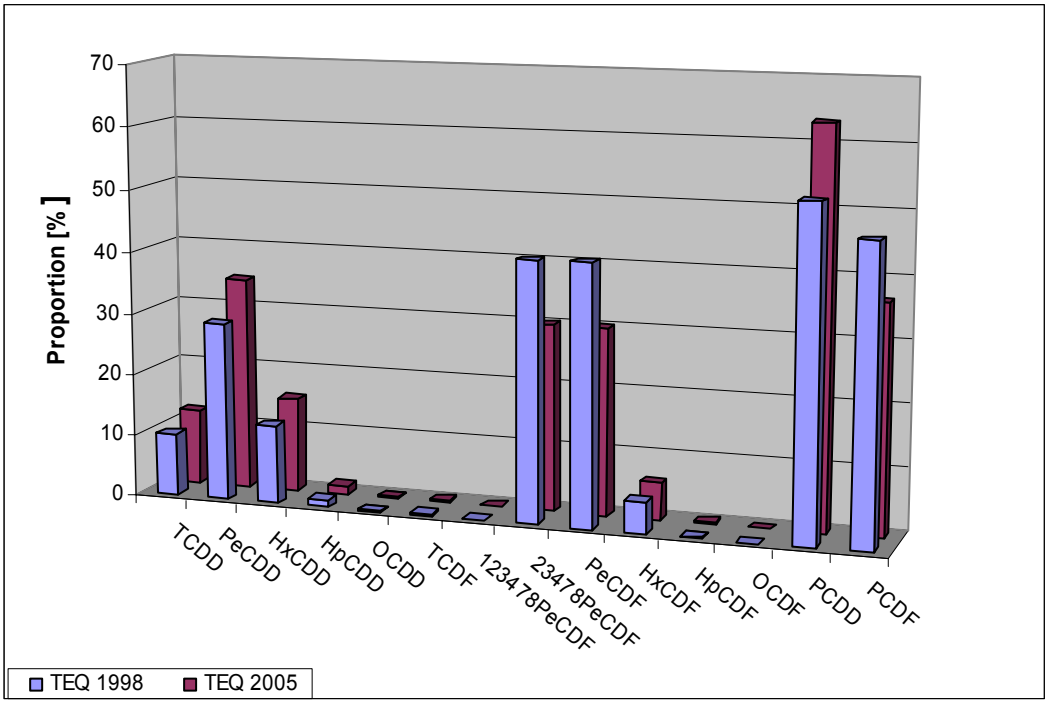
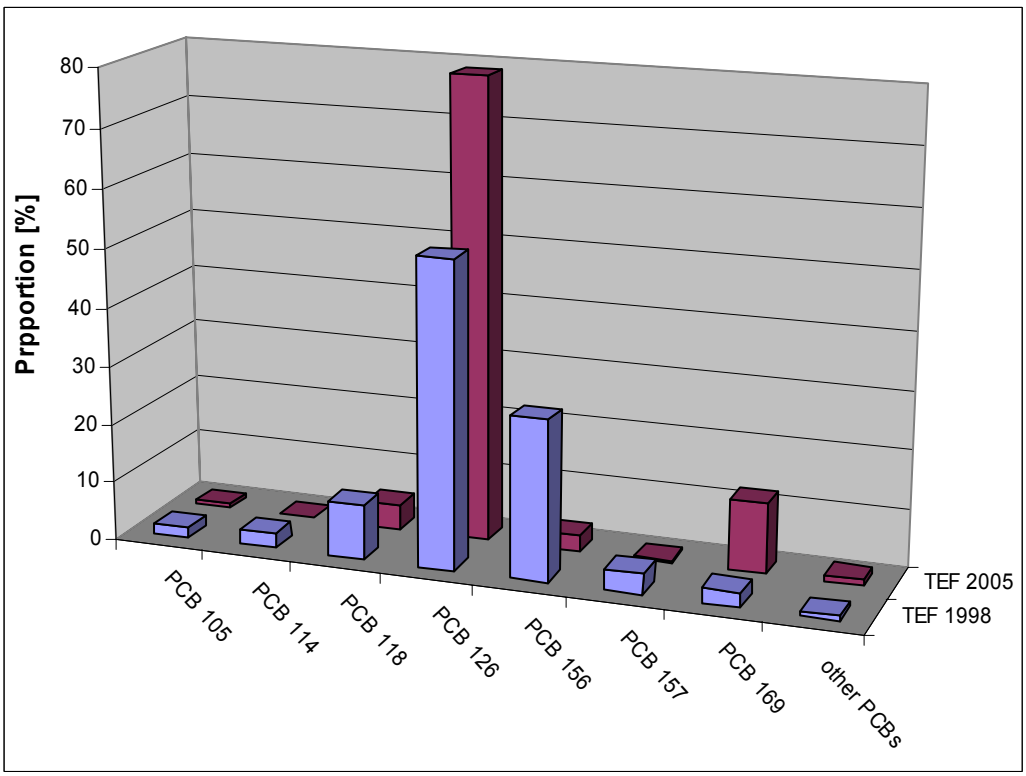


Figure 16: Percentage of PCB-congeners in WHO-PCB-TEQ in breast milk



References

[1] BfR, 2006: BfR rät von einer Übernahme der neuen Toxizitätsäquivalentfaktoren (WHOTEF) in die gesetzlichen EU-Regelungen für Lebens- und Futtermittel ab, Stellungnahme Nr. 003/2007 des BfR vom 04. September 2006 http://www.bfr.bund.de/cm/208/bfr_raet_von_einer_uebernahme_der_neuen_toxizitaetsaequivalentfaktoren_ab.pdf