LEVELS OF PCDD/Fs AND PCBs IN MEAT AND LIVER OF DIFFERENT ANIMAL SPECIES AND COMPARISON WITH REGULATORY LIMITS

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Introduction

A monitoring programme conducted in 2009 on levels of PCDD/Fs and PCBs in sheep liver showed that the current European Union (EU) maximum levels were frequently exceeded. As a consequence, further investigations on the levels of these contaminants in liver of other animal species intended for human consumption were performed. Meat and liver samples of chickens, pigs, cattle and calves were analysed for PCDD/Fs and PCBs for a comprehensive overview of the levels of contamination of these tissues, and to compare those levels with regulatory limits.

Current EU maximum levels set for liver are established on a fat basis. The European Food Safety Authority (EFSA) was asked by the European Commission to provide scientific evidence of the appropriateness to establish levels in liver on fresh weight basis rather than on fat basis in future legislation[1]. In this context, the European Union-Reference Laboratory (EU-RL) for Dioxins and PCBs in Feed and Food conducted a study to evaluate the influence of the application of different methods for extraction of lipids from sheep liver with regard to reporting results on fat or fresh weight basis[2].

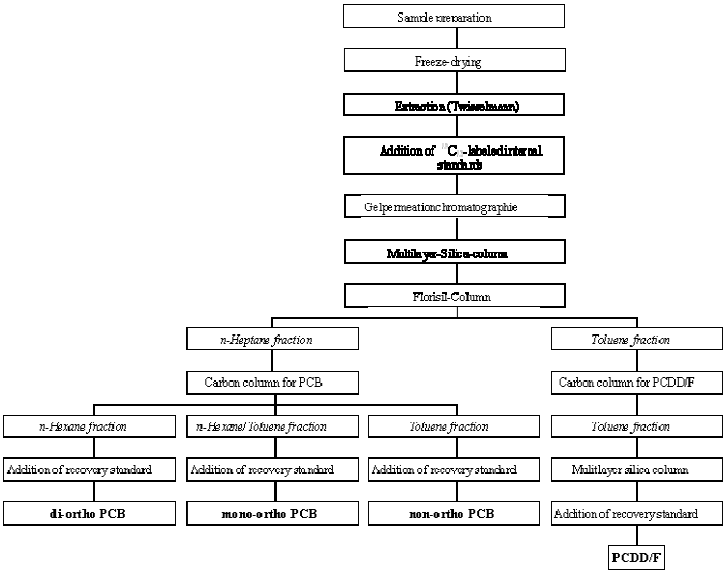
Materials and methods

Sampling

A total of 126 meat and 118 liver samples of sheep, chickens, pigs, cattle and calves were analysed for PCDD/Fs and PCBs. The samples were collected between 2009 and 2012 according to Commission Regulation (EC) No 1883/2006[3] (until 2011) and Commission Regulation (EU) No 252/2012[4] (since 2012) as part of the official food control in Baden-Wuerttemberg. Liver and meat (except calf's) originated from the same animal respectively.

Analysis

The samples were analysed for PCDD/Fs and PCBs applying the extraction and clean-up steps given below, followed by GC-HRMS measurement:



GC-HRMS measurement:

- PCDD/Fs
  - PTV injector: Injection of 5 µl (solvent split)
  - GC separation: 95%-Dimethyl-5%-diphenyl-polysiloxane
  - HRMS: Resolution 10'000

- PCBs:
  - SSL injector: Injection of 1 µl splitless
  - GC separation: HT-8 PCB
  - HRMS: Resolution 10'000

Results and discussion

Regulatory limits for PCDD/Fs, dl-PCBs and indicator PCBs in meat and liver of ruminants, poultry and pork
Commission Regulation (EC) No 1881/2006[5] of 19 December 2006 setting maximum levels for PCDD/Fs and PCBs in certain foodstuffs was amended by Commission Regulation (EU) No 1259/2011[6] of 2 December 2011. In this context new EU maximum levels for PCDD/Fs and the sum of PCDD/Fs and dioxin-like PCBs (dl-PCBs) were introduced. These new legal limits are based on WHO-toxic equivalency factors established in 2005 (TEF_{2005})[7] instead of TEFs previously published in 1998 (TEF_{1998})[8]. For the first time also EU-harmonized maximum levels for the sum of six indicator PCBs (PCB 28, 52, 101, 138, 153 and 180) were set for different foodstuffs. This sum is considered a suitable indicator for the occurrence of non-dioxin-like PCBs (ndl-PCBs) and the exposure of humans to PCBs. The new legal limits are applicable since January 2012.

Maximum levels for PCDD/Fs, the sum of PCDD/Fs and dl-PCBs, and for the sum of indicator PCBs in meat and liver are listed in the following table.

Foodstuffs	WHO-PCDD/F-TEQ [pg/g fat]	WHO-PCDD/F-PCB-TEQ [pg/g fat]	Sum of indicator PCBs [ng/g fat]
	TEF_{1998} / TEF_{2005}	TEF_{1998} / TEF_{2005}	
Meat of bovine animals and sheep	3.0 / 2.5	4.5 / 4.0	40
Meat of poultry	2.0 / 1.75	4.0 / 3.0	40
Meat of pigs	1.0 / 1.0	1.5 / 1.25	40
Liver of terrestrial animals	6.0 / 4.5	12.0 / 10.0	40

Table 1: Maximum levels for PCDD/Fs, the sum of PCDD/Fs and dl-PCBs, based on TEF_{1998} (applicable until 2011) and TEF_{2005} (applicable since 2012), and for the sum of indicator PCBs (applicable since 2012)

Results of samples analysed in the years 2009 - 2011 (sheep, chicken, pig and cattle) were calculated using WHO-TEF_{1998} and evaluated with the legal limits in force at that time. Only results of the calf samples, analysed in 2012, were calculated with new TEF_{2005} using new maximum levels for evaluation.

Number of analysed samples
- A total of 37 sheep liver and 35 sheep meat samples were analysed for PCDD/Fs and PCBs in 2009. Investigations were continued in 2011 with the analyses of 16 further samples of sheep meat and liver. The meat originated from the same animal as the liver in all cases. 39 animals were from Baden-Wuerttemberg (Germany), 14 from other European countries.
- 22 samples of bovine liver and 20 samples of meat (from the same animals as the livers) were analysed for PCDD/Fs and dl-PCBs in 2010.
- In 2011, 18 samples of chicken liver and meat, as well as 12 samples of pig´s liver and meat (in all cases from the same animals as the livers) were analysed.
- In a monitoring programme carried out in 2012, investigations were extended to calf´s liver (13 samples) and veal (25 samples). In four cases, meat originated from the same animal as the liver.

Lipid-based PCDD/F and PCB results of liver of different animal species
- A significant proportion of sheep liver samples were found to be not compliant with legal limits: approximately 85 % exceeded the maximum permitted levels numerically, 65 % when taking into account the measurement uncertainty.
- Only one bovine liver exceeded the maximum level for PCDD/Fs taking into account the measurement uncertainty. Another sample contained levels numerically above the maximum level for the sum of PCDD/Fs and dl-PCBs.
- All chicken and pig´s liver showed PCDD/F and PCB levels below the legal limits.
- One sample of calf´s liver exceeded the maximum level for the sum of PCDD/Fs and dl-PCBs. In addition, four liver samples contained levels of indicator PCBs above the new maximum level of 40 ng/g fat (applicable since January 2012) taking into account the measurement uncertainty.

Lipid-based PCDD/F and PCB results of meat of different animal species
PCDD/F and PCB levels in meat were significantly lower than in livers irrespective of the animal species.

- Two samples of sheep meat showed values in the range of the maximum permitted level for the sum of PCDD/Fs and dl-PCBs, the other sheep meat samples were below the maximum levels.
- All samples of beef, chicken and pork contained PCDD/F and PCB levels well below the maximum permitted levels.
- None of the tested veal samples exceeded the maximum levels applicable since 2012.

Comparison of lipid-based levels in meat and in liver of different animal species

Irrespective of the animal species, levels of PCDD/Fs and PCBs in livers were considerably higher than in meat samples of the same animals. A significant correlation between levels in liver and in meat of the respective animal was not observed.

Regarding the liver, the highest levels were found in liver of sheep. The analysed bovine and calf´s liver samples contained lower PCDD/F and dl-PCB levels than sheep liver but still significantly higher than the analysed chicken and pig´s liver (see figure 1).

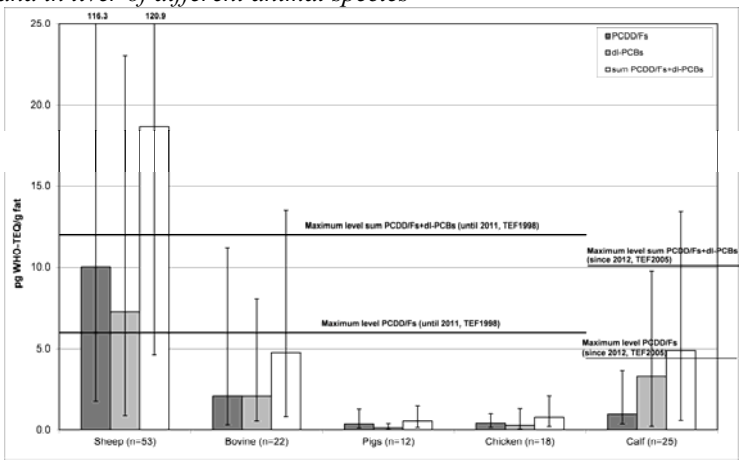


Figure 1: Median of PCDD/F and dl-PCB levels in liver of different animal species, minimum and maximum

Comparable to the liver, levels in chicken meat and pork were lower than in beef and sheep meat. PCDD/F and dl-PCB levels in beef and sheep were in a similar range (see figure 2). Veal samples contained quite low PCDD/F and PCB levels. It has to be mentioned that the results of calf´s liver and veal in figure 1 and 2 are calculated using TEF_{2005} whereas the other results are based on TEF_{1998}.

Differences arise in the ratio of levels of PCDD/Fs and dl-PCBs: In all animal species except calf the contribution of PCDD/Fs to the total-TEQ (sum of PCDD/Fs and dl-PCBs) in liver is significantly higher than in the meat, even if liver and meat originate from the same animal.

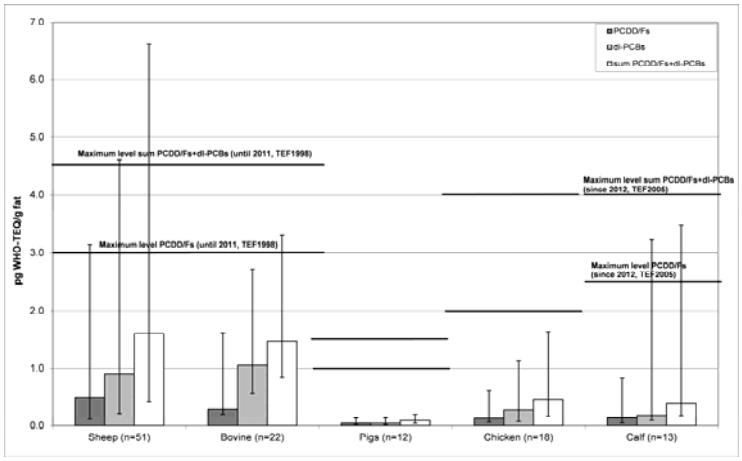


Figure 2: Median of PCDD/F and dl-PCB levels in meat of different animal species, minimum and maximum

Maximum levels for indicator PCBs in liver and meat

EU maximum levels for indicator PCBs in meat and liver are both set at 40 ng/g fat. For comparison: the maximum level for the sum of PCDD/Fs and dl-PCBs and for PCDD/Fs in liver is by a factor of 2 - 2.5 higher than for meat. Figure 3 shows that these maximum levels established for indicator PCBs are not adjusted to the average background contamination of meat and liver, because levels in liver of sheep, beef and calf are generally higher than in meat. Therefore, it is possible that liver samples already exceed the maximum level defined for indicator PCBs while levels of PCDD/Fs and dl-PCBs are below the existing maximum levels.

Calculation of results of liver on a fresh weight basis

For the purpose of comparison, results of liver on a fat basis were recalculated on a fresh weight basis. Fat contents of the liver samples ranged between 2 and 12 % (median: 4.2 %). In table 2, data for the sum of PCDD/Fs and dl-PCBs in sheep liver and in bovine, chicken and pig´s liver are provided on fat and on fresh weight basis respectively. The median level of sheep liver (0.8 pg WHO-PCDD/F-PCB-TEQ/g fresh weight) is more than a factor of 10 above the median level of bovine, chicken and pig´s liver (0.06 pg WHO-PCDD/F-PCB-TEQ/g fresh weight).

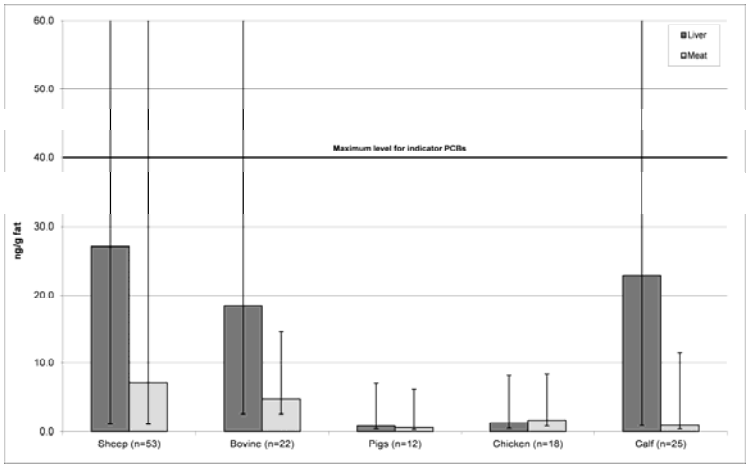


Figure 3: Median of indicator PCB levels in liver and meat of different animal species, minimum and maximum

Possible explanations for these different levels might be differences in metabolism and storage in the liver of the different animal species[1].

WHO-PCDD/F-PCB-TEQ	Sheep liver		Bovine, chicken and pig´s liver	
	pg/g fat	pg/g fresh weight	pg/g fat	pg/g fresh weight
Median	18.7	0.8	1.3	0.06
75 % Percentile	27.3	1.4	3.9	0.14
95 % Percentile	76.1	4.1	9.5	0.31

Table 2: Sum of PCDD/Fs and dl-PCBs in liver calculated on fat and on fresh weight basis respectively

Conclusions

Levels of PCDD/Fs and PCBs were found to be considerably higher in livers than in the corresponding meat samples. A significant correlation between contents in liver and in meat of the respective animal was not observed. Livers of different animal species contained rather different average PCDD/F and PCB concentrations; the highest levels were found in liver of sheep. Regular control of liver of different animal species intended for human consumption seems to be important to monitor the contribution of liver to the human intake of PCDD/Fs and PCBs.

References

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