# DISTRIBUTION OF PCDD/Fs, PCBs and PBDEs IN SEMIDOMISTICATED REINDEER *(RANGIFER TARANDUS TARANDUS L.)* MEAT AND LIVER

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## Introduction

During the years 2003-2005 it was found in a regular Finnish food supplies monitoring program that the meat of reindeer calves contained rather high concentrations of polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) and polychlorinated biphenyls (PCBs)[1]. Concentrations of WHO-PCDD/F-PCB-TEQs were in the range of 3.5-6.7 pg $g^{-1}$ fat, which exceeded the limit value in foodstaffs for bovine animals and sheep[2]. As majority of the reindeer meat on the market originates from slaughtered calves it was considered important to investigate the topic more closely. A survey investigating the concentrations of persistent organic pollutants (POPs) in adult reindeer and reindeer calf meat and tissues and their areal distribution in Finnish reindeer herding region was conducted in 2006-2008[3-5]. As the results indicated POPs to transfer from adult reindeer to fetus and calf via placenta and lactation, we wanted to investigate the subject more closely. To deepen the understanding of transfer of POPs in reindeer, we launched a project in 2010 studying supply and accumulation of PCDD/Fs, PCBs and polybrominated diphenylethers (PBDEs) in adult reindeer females and their offspring. The distribution of PCDD/Fs, PCBs and PBDEs in reindeer hinds and their offspring meat and liver is presented here.

## Materials and methods

Meat and liver samples from five adult reindeer (age about ten years) with either fetuses or calves were analysed for POP concentrations. Two calves of these reindeer were about 3.5 months old, and two fetuses on about gestation day 200 when slaughtered in 2010. One adult 11-year-old reindeer (Adult female 5) with fetus (Fetus 5; gestation day of approximately 120) was slaughtered previously in 2008. Five adult female reindeer meat and two calf meat samples consisted of 200 g rump, 200 g rib and fore back, and 100 g shoulder muscle, which were analyzed as a pool. In addition, meat samples were collected from three fetuses equally. Liver samples were collected from the said five adult female reindeer, two calves and two fetuses. The liver from the smallest fetus (Fetus 5) was not collected. Both meat and liver sampling was conducted using a clean knife and nitric gloves to prevent contamination. The samples were stored in polyethylene bags and preserved at -20°C until the analysis was accomplished.

The samples were freeze dried after homogenization and fat was extracted with toluene-ethanol using Accelerated Solvent Extractor (ASE 300) equipment. Solvent was then exchanged to hexane and the fat content was determined gravimetrically. Further the samples were defatted on an acidic silica column and purified and fractionated on alumina and carbon columns. PCDD/Fs, PCBs and PBDEs were analyzed with HRGC/HRMS using SIR and resolution of 10 000. Further details of the analytical method can be found elsewhere[3].

The measured PCDD/F congeners included 17 toxic 2, 3, 7, 8 -chlorine substituted congeners and the 37 PCB congeners included the 12 dioxin-like PCBs. 15 PBDEs consisted of PBDE congeners BDE-28, -75,-71, -47, -66, -77, -100, -119, -99, -85, -154, -153, -138, -183, and 209. Analyzes were performed in the Unit of Chemical Exposure at the National Institute for Health and Welfare, THL, in Finland. The Unit is an accredited testing laboratory (No T077) according to EN ISO/IEC 17025 requirements, and the scope of accreditation includes PCDD/Fs, PCBs and PBDEs from foodstuffs.

**Results and discussion**

The fat based WHO-TEQ (1998) concentrations of PCDD/Fs and PCBs and sum PBDE concentrations in reindeer meat and liver samples are shown in Tables 1 and 2.

Table 1.Lowerbound concentrations of PCDD/Fs, PCBs and PBDEs in reindeer meat samples

| Meat sample | Fat% | PCDD/F-TEQ (pg/g fat) | PCB-TEQ (pg/g fat ) | PBDE (sum of 15 congeners; ng/g fat) |
|---|---|---|---|---|
| Adult female 1 | 1.6 | 0.25 | 0.44 | 3.94 |
| Calf 1 | 3.2 | 0.52 | 2.19 | 2.69 |
| Adult female 2 | 3.7 | 0.06 | 0.29 | 1.94 |
| Calf 2 | 4.8 | 0.08 | 0.88 | 0.50 |
| Adult female 3 | 2.3 | 0.26 | 1.11 | 3.84 |
| Fetus 3 | 2.2 | 0.22 | 0.73 | 2.89 |
| Adult female 4 | 4.0 | 0.18 | 0.60 | 2.09 |
| Fetus 4 | 2.2 | 0.14 | 0.29 | 6.42 |
| Adult female 5 | 2.7 | 1.07 | 1.17 | 2.04 |
| Fetus 5 | 2.1 | 2.06 | 1.14 | 23 |

The meat from reindeer calves had both PCDD/F-TEQ and PCB- TEQ concentrations higher than meat from their equivalent hind, the phenomenon that has been seen in our previous studies as well[1, 3-4]. The meat from Fetus 5 contained higher PCDD/F-TEQ concentration than the meat from Adult female 5, but the other two fetuses had smaller concentrations of both PCDD/F- and PCB-TEQs than their equivalent hinds. The meat from the adult female reindeer contained higher concentrations of PBDE than their offspring calves, as in previous studies[5]. However, when comparing the PBDE concentrations in the meat of an adult female and their fetus a contradictory trend could be found. Two fetuses had higher meat concentrations of PBDEs than their hinds, which refers to placental transfer of PBDEs[5]. The fact that PCDD/F and PCB concentrations were higher in calves but not in fetuses than in their equivalent hinds suggests that lactational transfer of PCDD/Fs and PCBs is of more importance to the exposure to these compounds rather than placental transfer.

Table 2. Lowerbound concentrations of PCDD/Fs, PCBs and PBDEs in reindeer liver samples

| Liver sample | Fat % | PCDD/F-TEQ (pg/g fat) | PCB-TEQ (pg/g fat) | PBDE (sum of 15 congeners; ng/g fat) |
|---|---|---|---|---|
| Adult female 1 | 5.3 | 32.1 | 24.9 | 0.42 |
| Calf 1 | 5.3 | 41.4 | 50.1 | 0.48 |
| Adult female 2 | 5.3 | 3.97 | 3.68 | 0.29 |
| Calf 2 | 5.5 | 11.2 | 16.0 | 0.31 |
| Adult female 3 | 4.1 | 30.0 | 27.9 | 0.52 |
| Fetus 3 | 2.0 | 0.83 | 0.79 | 0.68 |
| Adult female 4 | 3.8 | 22.9 | 17.8 | 0.62 |
| Fetus 4 | 1.6 | 0.34 | 0.32 | 1.18 |
| Adult female 5 | 4.0 | 124 | 41.2 | 4.10 |

Higher concentrations of PCDD/Fs and PCBs were found in the liver of adult reindeer and calves than in their meat (See Figure 1). However, for fetuses, even though the PCDD/F concentrations were higher in the liver tissue than in the corresponding meat, the PCB concentrations were interestingly almost the same in both matrices.
PBDE concentrations were lower in the liver samples compared with the equivalent meat samples, except in Adult female 5, which had higher concentrations of PBDEs in the liver sample. The calves's liver samples contained evidently more PCDD/Fs and PCBs than adult reindeer's liver samples, which was seen in previous study as well[5].
The PBDE concentrations were almost the same in the liver samples of adult female reindeer and the equivalent calves 1-2, and a bit higher in the fetus liver compared to the liver of an adult reindeer.

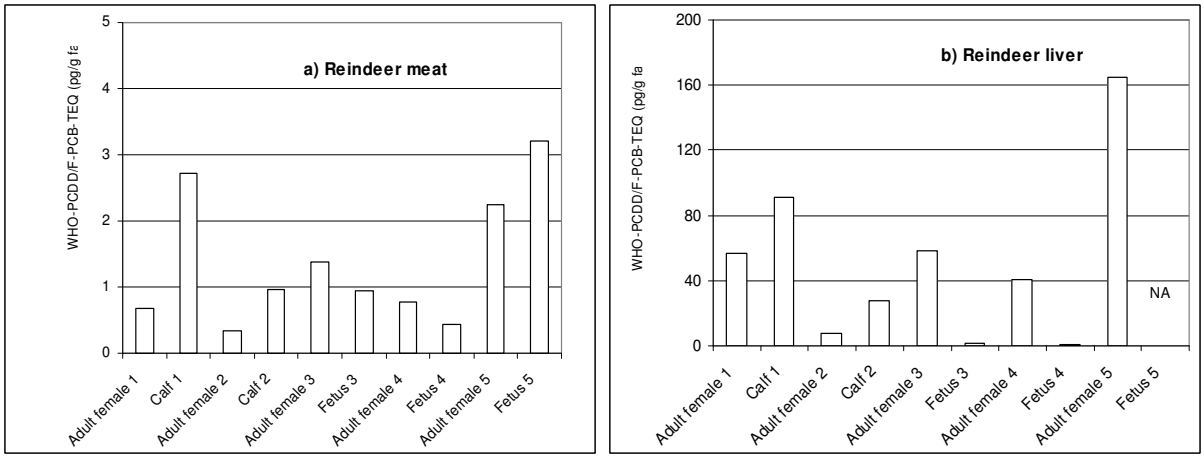


**Figure 1.** PCDD/F-PCB-WHO-TEQ concentrations in a) reindeer meat and b) reindeer liver (NA= not analyzed)

Based on these results, it is obvious that reindeer liver collects effectively highly toxic substances, especially PCDD/Fs and dioxin-like-PCBs. The transfer of PBDEs seems to deviate considerably from the PCDD/Fs and dioxin-like-PCBs. To deepen the understanding of these processes, further research on the concentrations of these substances in reindeer milk, placenta and other tissues will be performed in the future.

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