LEVELS OF PCDD/Fs AND PCBs IN REINDEER - FIRST RESULTS OF THE FINNISH STUDY ON POPs IN REINDEER FOOD CHAIN

Ruokojärvi P[1], Laaksonen S[2], Suutari A[2], Kiviranta H[1], Vartiainen T[1]
[1]National Public Health Institute, P.O Box 95, FI-70701 Kuopio, Finland; [2] Finnish Food Safety Authority Evira, P.O Box 517, FI-90101 Oulu, Finland

Abstract
Polychlorinated dibenzo-*p*-dioxin (PCDD/F) and polychlorinated biphenyl (PCB) concentrations were monitored in Finnish reindeer (*Rangifer tarandus*). PCDD/F and PCB concentrations were higher in reindeer calf meat than in the meat of an adult reindeer. Majority of the combined WHO-PCDD/F-PCB-TEQ values comprised of WHO-PCB-TEQs throughout the samples. It was found that reindeer meat from the Northern Lapland contained lower concentrations of PCDD/Fs and PCBs than reindeer meat from Middle Lapland or meat from the southern parts of the reindeer management area. Although reindeer calves that were born dead had measurable quantities of PCDD/Fs and PCBs, the analysis of reindeer milk revealed that reindeer calves are considerably exposed to PCDD/Fs and PCBs via reindeer milk during their nursing period.

Introduction
Reindeer management is an important part of northern Finnish culture and often one of the few possible livelihoods in distant arctic areas. One third of the reindeers (*Rangifer tarandus*) in Finland (approximately 300 000 reindeer) are butchered yearly and 70 % of these butchered animals are calves. When monitoring of Finnish food supplies was performed in 2003-2005 [1], it was noticed that the levels of PCDD/Fs and PCBs were elevated in reindeer calves, and their WHO-PCDD/F-PCB-TEQ concentrations exceeded limit values for ruminants[2]. There have been only few studies on PCDD/F and PCB concentrations in reindeer meat or liver, and in most studies only PCB concentrations with various number of PCB congeners have been analyzed[3]. Those reports that have studied both PCDD/F and PCB concentrations in Canadian Arctic caribou (*Rangifer tarandus*) have shown low levels of these contaminants in the animal[4] whereas quite high levels of WHO-PCDD/F-TEQs (0.75-20 pg WHO-PCDD/F-TEQ/g fat) have been reported from the Russian Arctic reindeer meat[5] .

The elevated PCDD/F and PCB levels found in Finnish reindeer calves in 2003-2005 launched a project in 2006 which aimed to learn more about the levels of PCDD/Fs and PCBs in reindeer, the causes of elevated levels in reindeer calves and intake of PCDD/Fs and PCBs by reindeer. These are the first results on PCDD/F and PCB concentrations in reindeer meat and milk.

Materials and Methods
Reindeer management area was roughly divided into three regions - Northern Lapland, Middle Lapland and southern part of the reindeer management area (Figure 1). Samples of reindeer meat were collected from these areas. Most of the samples were reindeer calves of which ten samples were reindeer calves that were born dead, so they had not been nursed by their dam. Also some adult reindeer meat was collected for analysis. Reindeer milk was analyzed from the northern Lapland reindeers both in early summer and in autumn.

Figure 1: Reindeer management area divided into three regions

Measured analytes were 17 2,3,7,8-substituted PCDD/F congeners and 37 PCB congeners, including 12 dioxin-like PCB-congeners and 6 indicator-PCB congeners.

Meat samples were freeze-dried after homogenization. Fat was extracted with ethanol-toluene (30/70 v/v) using Accelerated Solvent Extractor (ASE 300). Milk samples were extracted with liquid-liquid extraction (diethylether-hexane). After extraction fat was determined gravimetrically and sample was defatted on acidic silica column and purified and fractionated on alumina and carbon columns. PCDD/Fs and PCBs were analyzed with HRGC/HRMS (VG 70-250) using selected ion monitoring mode with a 10,000 resolution. PCDD/Fs and PCBs were separated on a DB-Dioxin column (60 m x 0.25 mm x 0.15 μm). Laboratory of Chemistry is an accredited testing laboratory (T077) in Finland. The scope of accreditation includes PCDD/Fs and PCBs from food samples.

Results and Discussion

Measured WHO-PCDD/F-PCB-TEQ concentrations in reindeer calves' meat were somewhat lower than in the previous study [1] (Table 1).

A difference can be observed in PCDD/F and PCB concentrations between adult reindeer meat and reindeer calf meat. Adult reindeer meat had a mean value of 2.3 pg WHO-PCDD/F-PCB-TEQ/g fat (n=3) and reindeer calf meat (not including the dead born calves) a mean value of 3.3 pg WHO-PCDD/F-PCB-TEQ/g fat (n=18), so the combined PCDD/F and PCB concentration is clearly higher in reindeer calves than in adult reindeers.

Table 1: Mean upperbound concentrations and ranges of PCDD/Fs and PCBs in reindeer meat and milk

	n	Fat %	WHO-PCDD/F-TEQ	WHO-PCB-TEQ	WHO-PCDD/F - PCB-TEQ
Reindeer sample			pg/g fat	pg/g fat	pg/g fat
Northern Lapland					
Meat, adult	1	4.3	0.69	0.79	1.48
Meat, calf	9	4.4 (2.1-6.1)	1.19 (0.97-1.65)	1.58 (1.01-2.49)	2.77 (2.09-4.14)
Meat, calf, stillborn	1	1.7	0.76	0.48	1.24
Milk, early summer collection	10	10.3 (8.9-13.7)	0.46 (0.32-0.58)	0.62 (0.25-0.98)	1.08 (0.57-1.53)
Milk, autumn collection	7	26.0 (15.5-29.8)	0.38 (0.30-0.56)	0.36 (0.26-0.45)	0.75 (0.62-0.88)
Middle Lapland					
Meat, adult	2	8.4 (7.8-9.0)	0.82 (0.73-0.91)	1.83 (1.58-2.07)	2.65 (2.31-2.98)
Meat, calf	9	5.5 (4.7-6.3)	1.22 (1.07-2.56)	2.63 (2.06-3.09)	3.84 (3.16-5.05)
Southern area					
Meat, calf, stillborn	10	2.1 (1.4-2.6)	2.03 (0.50-6.20)	4.04 (0.22-21.30)	6.07 [a)] (0.72-27.50)

[a)] If highest concentration (27.5 pg WHO-PCDD/F-PCB-TEQ) is removed, the combined WHO-PCDD/F-PCB-TEQ concentration is 3.69 pg/g fat.

The results show that most of the combined WHO-PCDD/F-PCB-TEQ-values are mainly due to PCBs in all of the studied areas, as was also observed in the previous Finnish food monitoring study[1]. Fat based PCB and PCDD/F concentrations are lower in the Northern Lapland reindeers than in other reindeers from the study areas. Since the fat percentage is also lower in Northern Lapland reindeers, the fresh weight concentrations are even lower in Northern Lapland reindeers than in those from other study areas. This may be due to their diet e.g. the PCDD/F and PCB fallout into reindeer's natural food (lichen, leaves and other plants) may be smaller in the Northern Lapland, or the supplementary feed may have smaller concentrations of PCDD/Fs and PCBs than the reindeers' natural diet. The adult Northern Lapland reindeers had received also some supplementary feed, whereas the reindeers from Middle Lapland had not.

The ratio of WHO-PCDD/F-TEQ to WHO-PCB-TEQ is higher in the Northern Lapland reindeers than in the reindeers from southern part of the reindeer management area. This can be a result of different PCDD/F to PCB concentrations in fallout and/or in their supplementary feed, but at least partly it is due to the fact that when very low PCDD/F concentrations are analyzed, the difference between upperbound and lowerbound values becomes wider, and when using the upperbound results in case of very small concentrations, PCDD/F-TEQ concentrations are emphasized, since the TEF-values of PCDD/Fs are higher than those of PCBs.

The PCDD/F and PCB concentrations among dead born reindeer calves varied notably between individuals. The fat based results of stillborn calves from southern study area were in general of the same magnitude than in Middle Lapland's calves that had already been nursed, if one sample with extremely high concentration is excluded (Table 1). One stillborn reindeer calf from Northern Lapland had low fat based WHO-PCDD/F-PCB-TEQ concentration. In general the fat percent of the stillborn calves was very low, and

when taking this into account, their mean fresh weight PCDD/F and PCB TEQ-concentration does not vary much from that of Northern Lapland calves, and if one extremely high result in dead born calves in southern study area is excluded, the fresh weight concentrations are clearly lower in stillborn calves than in other calves.

The fat based WHO-PCDD/F-PCB-TEQ reindeer milk concentrations were higher in the milk samples collected in early summer than in the samples collected in autumn (Table 1). However, the fat percent of the milk more than doubled during the lactation period and the fresh weight based concentrations were even raised during the lactation period. Lactation period lasts normally from 24 to 26 weeks, and at that time the total milk production amount is almost 100 kg[6], so the reindeer calves do expose to PCDD/Fs and PCBs via milk considerably.

So, although the reindeer calves are exposed to PCDD/Fs and PCBs already in uterus, the high WHO-PCDD/F-PCB-TEQ -concentrations in reindeer calves seem to be to a great extent a result of their intake of PCDD/Fs and PCBs via reindeer milk.

Acknowledgements
Mr. Mauri Nieminen, Mrs. Katri Mehtonen, Mrs. Heli Välipakka and Mrs. Eija Mehtonen are gratefully acknowledged for technical assistance.

References

1. Kiviranta H, Hallikainen A, Ruokojärvi P, Rantakokko P, Vartiainen T. *Organohalogen Compounds* 2006; 68:1898.
2. Council Regulation EC 2375/2001
3. AMAP Assesment. Report Arctic Pollution Issues. Arctic Monitoring and Assessment Programme, Oslo, Norway, 1998, 859 p.
4. Hebert CE, Gamberg M, Elkin BT, Simon M, Norstrom RJ. *The Science of the total Environment* 1996;185: 195.
5. Persistent Toxic Substances, Food Security and Indigenous Peoples of the Russian North. AMAP Report 2004:2. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway, 2004, 192 p.
6. Gjøstein H, Øystein H, Weladji RB. *Comparative Biochemistry and Physiology-Part A: Molecular and Intergrative Physiology* 2004;137: 649.