# Concentrations of PCDD/Fs and PCBs in Rainbow Trout Fed with Baltic Herring and Dry Fish Feed

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## Introduction

The main source of dioxin and PCB exposure is the dietary intake of these contaminants with meat, fish and dairy products. PCDD/Fs and PCBs are lipophilic compounds, and they accumulate in fat tissues. It has been estimated that fish consumption contributes to the dietary exposure of Finns by 63% and 70% for PCDD/Fs and PCBs, respectively. Rainbow trout and Baltic herring represent 41% of fish consumption in Finland (1). Baltic herring may accumulate organic contaminants present in the sediments and water of the Baltic, whereas the concentrations in farmed rainbow trout reflect the concentrations of fish feed used. Rainbow trout are mainly fed with dry fish feed, but it has been considered whether the amount of Baltic herring used as a feed could be increased.

In this study, rainbow trout were fed with Baltic herring and dry fish feed. The fish were sampled periodically for the determination of PCDD/F and PCB concentrations in their tissues. The effects of the two feeds on the accumulation of contaminants were compared.

## Materials and Methods

Rainbow trout were farmed in six net cages. Fish in three cages were fed with Baltic herring caught from the Baltic. Fish in three other cages were fed with dry fish feed, mainly consisting of fish meal (60%), fish oil (17%) and wheat meal (16%) (2). The concentrations of PCDD/F and PCB in both feeds, in fish oil and in rainbow trout sampled from the cages were determined. During the four-month trial fish were sampled once a month, and five individuals from each

cage were pooled to form a representative sample. PCDD/F and PCB concentrations in fish oil samples were analyzed from twelve lots of fish oil with different origins, and they represent the average concentrations, not exactly the fish oil used in the dry fish feed.

For the PCDD/F and PCB analyses about 10 g of freeze dried sample was soxhlet extracted for 24 h with toluene, and the fat content was determined gravimetrically. The extract was spiked with 100 pg of $^{13}$C-labeled PCDD and PCDF standards (seventeen 2,3,7,8-chlorinated PCDD/F congeners), with 100 pg of $^{13}$C-labeled non-*ortho*-PCB standards (PCB 77, 126, and 169), and with $^{13}$C-labeled PCB standards (PCB 18, 80, 101, 153, 180, Cambridge Isotope Laboratories). The extract was purified in a silica gel, and cleaned up with activated carbon column (Carbopack C, 60/80 mesh) containing Celite (Merck 2693) to separate PCDD/Fs from PCBs and further cleaned with an activated alumina column (Merck 1097, standardized, activity level II-III). The separated PCB fraction was further purified with another activated carbon column (without Celite) and the non-*ortho* PCBs were analyzed with a high resolution mass spectrometry equipped with a fused silica capillary column (DB-DIOXIN). The quantitation was performed by selective ion recording using a VG 70 SE mass spectrometry (resolution 10,000) (3). Levels of 17 most toxic PCDD/Fs were expressed in TCDD toxic equivalent factors (I-TEFs) (4) and PCB TEFs those recommended by WHO in 1994 (5).

**Results and Discussion**

A sharp increase in both PCDD/F and PCB levels was observed in rainbow trout fed with Baltic herring, whereas the feeding on dry fish feed only led to a minor accumulation of the contaminants. The accumulation of PCDD/Fs in rainbow trout fed with Baltic herring and dry fish feed is shown in Figure. Accumulation was nearly linear in the herring-fed fish, and the average PCDD/F concentration (sum of all congeners) after four months was 28.1 pg/g on the fresh weight basis. The concentration was 6.6 times higher than at the beginning of the trial (4.27 pg/g). PCDD/F accumulation was also calculated using I-TEqs. The I-TEqs at the end of the experiment were 11 times higher (9.63 pg I-TEq/g) than at the beginning (0.88 pg I-TEq/g), calculated on fresh weight basis. These results indicate that the toxic congeners, particularly, were accumulated in fish tissues.

PCB concentrations in rainbow trout fed with Baltic herring increased similarly to the PCDD/F concentrations. After four months the average fresh weight concentration was 99.1 ng/g, which was 5.3 times higher than at the beginning (18.8 ng/g). Accumulation of PCB TEqs resulting fresh weight concentrations were 6.4 times higher than in the reference samples, 34.7 and 5.45 pg PCB TEq/g, respectively. The accumulation of PCB TEqs did not significantly differ from the accumulation of all congeners.

The total PCDD/F sum concentrations were 29.7 pg/g fresh weight in Baltic herring and 22.1 pg/g fresh weight in dry fish feed. The difference in the PCDD/F concentrations was bigger if the concentrations were calculated using the I-TEqs: 9.32 and 4.03 pg/g for Baltic herring and dry fish feed, respectively, which shows that the PCDD/F amount in Baltic herring represented twice as high toxicity as the PCDD/F amount in the dry feed. The PCB sum concentration was

42.7 ng/g fresh weight in Baltic herring, and 47.1 ng/g fresh weight in dry fish feed. The feeds did not differ significantly neither in PCB sum concentrations nor in PCB toxicity values. The TEqs were 13.4 pg/g TEq for Baltic herring and 16.4 pg/g TEq for dry fish feed.

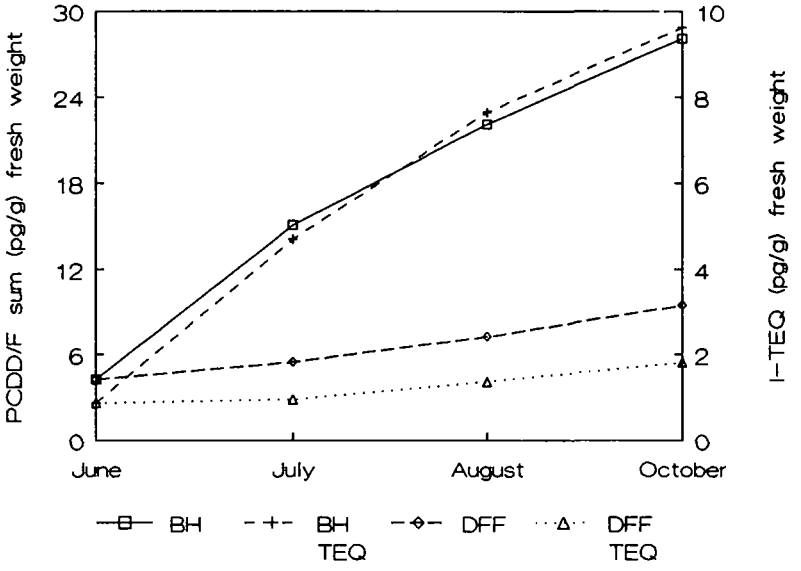


Figure. PCDD/F concentrations in rainbow trout fed with Baltic herring (BH) and dry fish feed (DFF). Total concentrations (pg/g) and I-TEqs (pg/g) in fresh weight.

The fish oil samples analyzed in this study contained low levels of PCDD/Fs and PCBs, 4.76 pg I-TEq/g fat and 23.2 pg TEq/g fat, respectively. The fish oil used as an ingredient of the dry fish feed could not have accounted for the whole PCDD/F and PCB load in the feed, unless, the particular batch of oil was exceptionally polluted. Therefore, other ingredients of the dry fish feed must have contributed to the total amount of PCDD/Fs.

The accumulation of PCDD/Fs and PCBs in rainbow trout was estimated by calculating the fractions of PCDD/F and PCB intake which remained in the rainbow trout fillet. The rainbow trout weighted about 0.5 kg at the beginning of the trial, and in four months the herring-fed trout reached an average weight of about 1.7 kg, while the trout fed with dry fish feed weighted 2.0 kg. The average fat content in trout which were fed with Baltic herring was 10% (fresh weight), and 21% in the trout fed with dry fish feed. The feed consumption of the rainbow trout was estimated to be 1.2 kg of feed (dry weight) per each kilogram of growth during the trial. Baltic herring contains almost 80% of water, and therefore the rainbow trout consumes much more Baltic herring (fresh weight) than dry fish feed. Using the figures given above, and the pollutant concentrations in both feeds plus the pollutant concentrations in rainbow trout fillet analyzed

before and after the trial, it was possible to calculate accumulation percents.

The percent of accumulation in the rainbow trout was 26% of the PCDD/F intake via the Baltic herring feed, and 39% via the dry fish feed. The PCB accumulation was 65% via the Baltic herring feed, and 100% via the dry fish feed. The accumulation percents above represent the PCDD/F and PCB contents given in toxicity equivalents. Using the total sum concentrations, the PCB accumulation percents were somewhat lower than these, while the accumulation of PCDD/Fs remained practically unchanced.

These results indicate that the accumulation of PCBs from both Baltic herring and dry fish feed was about 2.5 times higher than the accumulation of PCDD/Fs. PCDD/Fs are known to be extremely tightly bound to organic matrix, so that the release of PCDD/Fs from the feed, bioavailability, may have been more restricted than the release of PCBs. Moreover, the figures show that the extent of accumulation from the dry fish feed was about 1.5 times higher than the accumulation from the Baltic herring.

It should be noted that the rainbow trout were cleaned before the analysis, so that the PCDD/F and PCB contents of the guts were excluded from the pollutant balances.

In Finland, National Food Administration recommends that if fish is eaten more than three times a week, varying species should be consumed. Rainbow trout and Baltic herring account for about 23 and 19 %, respectively, of the total fish consumption. Baltic herring contain high amounts of PCDD/Fs and PCBs, as can be found from the Baltic herring analyzed in this study. For that reason, it is extremely important to keep rainbow trout as clean from environmental pollutants as possible to reduce the total exposure to environmental pollutants.

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