PCBs IN NORTH SEA FISH: IS THERE A HEALTH RISK?

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Introduction

The potential danger for food contamination, fish included, with PCBs and dioxins results in the first place from dioxin-like compounds. The daily intake of these dioxin-like substances exceeds for the major part of the Belgian population the Tolerable Daily Intake proposed by WHO and the Belgian Health Council (TDI of 1 pg TEQ/kg bw/d). A serious decrease of the daily intake of these dioxin-like substances can only be achieved by a general, important reduction of these contaminants in our food and/or a drastic modification of our dietary habits. Each proposition to change our dietary habits should take into account the positive characteristics of the concerned food products. Fish consumption for example also offers a number of favourable effects, which have to be put in balance with the negative ones such as the presence of contaminants.

Fish contains more dioxin-like substances per gram of fat than most of the other food products. Rough estimates made by the Belgian Health Council based on a limited dietary questionnaire exercise, indicate that fish contributes to the assimilation of 10 % of those substances by 45 % of the population and of 50 % by 3 % of the population. They also concluded that even a drastic measure, involving the removal of 25 % of the most contaminated fish species from the market, would only have a very limited impact on the daily intake of dioxin-like substances for the average individual. However, the impact would be much stronger for people consuming regularly fish and fish derived products.

Control of fish contamination by dioxin-like substances with respect to the WHO TDI-norm, can be performed directly via dioxin TEQ determinations (e.g. the CALUX-method[1]) or indirectly by marker PCB analyses. In the second case, a correlation between TEQ-values and marker PCB concentrations should exist and be established.

In this paper we will discuss marker PCB levels assessed in some North Sea fish species and their significance with respect to the TDI concept.

Methods and Materials:

Sampling

Thirty fish samples including St. James' shells, whelks, cod, whiting, sand sole, plaice, and lemon sole were collected in the North Sea. In addition, 7 trout species were obtained from a fish farm in Belgium. Muscle tissue was used for determination of wet weight, % water, % fat and chemical analyses of marker PCBs.

Chemical analysis of marker PCBs (Method based on the normalized CEN method, Ref. No. prEN 1528-1-1996 E)

After homogenisation of the fish, the fat is extracted with a mixture of Hexane/Acetone 1/1 in presence of 25 g of anhydrous sodium sulphate. Acetone is removed with an aqueous Na_2SO_4 solution (2%). The seven isotopic 13C-PCB markers are added and 0.4 g of fat is purified on a silica acid column (6g of silica/H_2SO_4 60/40, 1 g of Al_2O_3 - 10% water and 0.5 g of anhydrous Na_2SO_4). After concentration, the eluted hexane is injected on an Ion-Trap Polaris-Q® from Thermofinnigan in MS/MS mode. Estimates of the PCB concentrations are based on 13C-PCB/12C-PCB ratios (Isotopic dilution) using a 5 points linear calibration. As a quality control, a Blanco solvent, a Blanco procedure and a control sample are run within each series.

Results and Discussion:

Results of the PCB congeners analyses show that PCB-153 is the most abundant congener in almost all samples (a few results are shown in Figure 1), with also a significant contribution of the 138-congener. It should be noticed that PCB-118, which has in our samples a moderate abundance, is the only marker PCB having also a TEF-value (Toxic Equivalent Factor) of 0.0001. The only way to arrive at TEQ-values based on marker PCB concentrations is to look to correlations between both measured values.

The PCB concentration (sum of 7 congeners) in our fish samples ranged from 0.51 to 15.0 when expressed in ng g^{-1} w.w. and from 119 to 1500 when expressed in ng g^{-1} fat. The fat percentage varied between 0.30 and 1.80 % of fresh muscle tissue (wet weight). Since PCBs are lyophilic compounds and hence, preferentially accumulate in the lipid tissues of the fish, it is worthwhile to investigate the relationship between the PCB levels and the fat content. When plotting all results (Figure 2), we observe that at higher fat content (> 1%) 2 distinct sample populations show up. The first group of species, including for example sand sole and lemon sole, shows a fairly constant PCB content, independent of the fat percentage. For the second group of species, including for example whelks, cod and whiting, it appears that the PCB content increases when the fat fraction increases. Therefore, a separate plot (Figure 3) has been made using only the data for whelks, cod and whiting. A good and positive correlation (r=0.81) was observed between the PCB concentration (ng g^{-1} fat) and the % of fat.

Figure 1: PCB congeners per species (ng/g-wet weight)

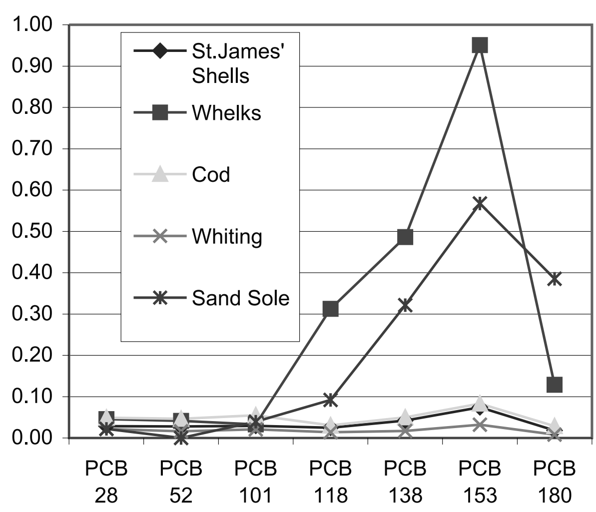
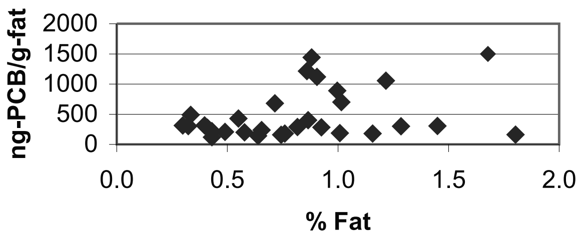


Figure 2. PCB versus % fat



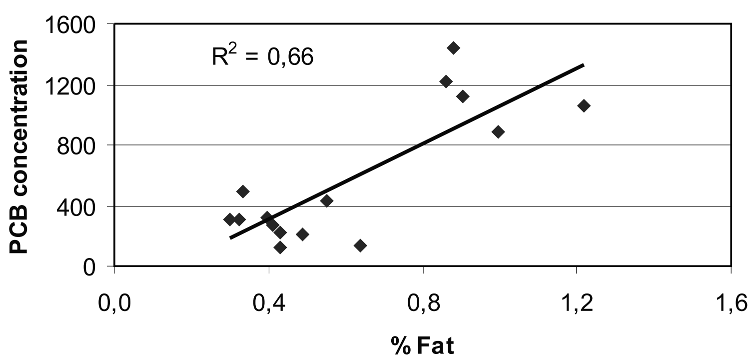
The discussion about the risk of eating fish contaminated with PCBs is still going on. WHO and the Belgian Health Council propose a TDI (Tolerated Daily Intake) of 1 pg TEQ/kg bw/d. Since most of the time only marker PCB results are available, an alternative solution is sought by fixing a maximum level (norm) in fish: standard values are 750 ng g^{-1} product (e.g. Belgium), 1000 ng g^{-1} product (e.g. Netherlands) etc., with exceptions for specific fish species or fish liver. It is clear that these norms are high and will not affect North Sea fish. When we look to fish farm samples such as trout, PCB levels are increased, but still below these norms (5 to 170 ng g^{-1} product). Assuming a 3 % fat content, we obtain for trout a maximum of 5700 ng g^{-1} fat.

The Belgian Health Council studied, on the basis of literature data for Western Europe, the relation between dioxin TEQs and marker PCBs. They found that the log-log correlation is the best when results are expressed per gram of fat (r=0.86), it is much weaker when results are expressed per gram of product (r=0.46). The correlation they found is:

$$\log (TEQ) = 0.4689 (\log PCB) + 0.0094.$$

In our case this means that a PCB concentration of 119 ng g^{-1} fat (the lowest contamination) corresponds to a TEQ-value of 9.6 pg g^{-1} fat and a PCB concentration of 1500 ng g^{-1} fat (the highest

Figure 3: PCB levels (ng/g-fat) versus % Fat
Whelks, cod, whiting



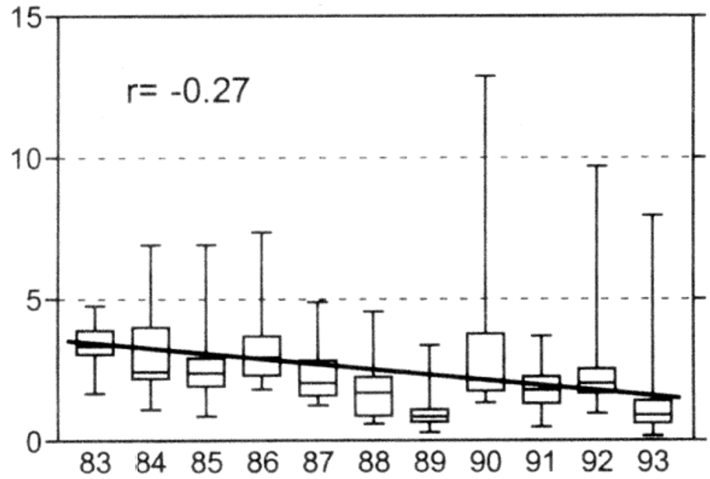


Figure 4. Evolution of PCBs (mg.g^{-1}) in Flounder

contamination) corresponds to a TEQ-value of 31.5 pg g^{-1} fat. Assuming an average fat percentage of 5 % for those North Sea fish species, we obtain a minimum of 0.48 pg-TEQ/g-fish and a maximum of 1.58 pg-TEQ/g-fish. A few years ago, Triangle Labs (Durham, US), performed for us dioxin analyses in 5 different North Sea fish samples: the highest dioxin concentration was found in lemon sole and amounted to 2.3 pg-TEQ/g-fish, slightly higher than the highest value we calculated from marker PCBs.

The TDI for a person of 75 kg weight, equals 75 pg-TEQ/d. Based on our marker PCB results, this means that he is allowed to consume between 10 and 30 grams fish/d if fish supplies 20 % of his dioxin-like daily intake. On the other hand, several studies have forwarded important health advantages such as the reduction of cardio-vascular diseases (e.g. Kromhout et al.[2]) and the low prevailing of diabetes (e.g. Feskens et al.[3]). Therefore, it is recommended that the Belgian population limit their fish consumption, for example for fat fish to 2 times a week.

Finally, an encouraging sign is the decreasing trend shown by the PCB levels observed in flounder during a 10 year survey (Figure 4).

Acknowledgements:

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