Levels of PCBs in salmon samples from Europe

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Introduction

Food, and fish in particular, is the most important source of exposure to dioxin and dioxin-like PCBs for the general population and concern is growing over recent estimates that the daily exposure to these compounds is higher than the tolerable level for a considerable part of the European population[1]. Measurement programs in the past focused mostly on dioxins, so the available data is insufficient to assess the current situation for dioxin-like PCBs. The figures for non-dioxin-like PCBs are still more uncertain, since they were always given lower priority, on account of their lower toxicity[1]. However, recent data spread doubts even about non-dioxin-like congeners, showing their ability to induce neurological and behavioral alterations in animals[2] and human infants and young children[3]. Recently, the European Commission adopted a strategy to reduce dioxins and PCBs in the environment, food and feed, with the aim of reducing human intake to below the safety level recommended by the EU Scientific Committee on Food[4]. With the aim to contribute to check variability in consumer exposure, we bought from retail outlets in four countries of the European Union (Italy, Belgium, Spain and Portugal) samples of salmon which were subsequently analysed for their content in PCBs.

Matherials and Methods

Food sample selection: Salmon samples analysed, ten for each country, were randomly bought from various shops, in different towns, distributed over the four countries. When of known origin, the salmon was generally farmed, and imported, mainly from Norway or Scotland, while frequently it was of unknown origin. Samples were subsequently frozen at –20°C and shipped to a centralised laboratory where they were analysed for their PCB contents.

PCB analysis: PCB congeners measured were IUPAC numbers 28, 52, 101, 118, 153, 138 and 180 (the most abundant, also called the "EC7"), 105, 114, 123, 156, 157, 167, 189 ("dioxin-like" mono-ortho PCBs), and 81, 77, 126, 169 ("dioxin-like" non-ortho PCBs). The specific congeners were all determined by high resolution gas chromatography-high resolution mass spectrometry. Briefly, stable ^{13}C labelled analogues of the PCBs were added to homogenised aliquots of each test sample. Samples were then extracted by 25% hydrochloric acid and 1:1 dichloromethane:hexane. Aliquots (25 g) of the homogenised samples were placed into glass jars and spiked with the internal standards. To each was then added 100 ml of 25% hydrochloric acid and 200 ml of 50:50 dichloromethane:hexane. The bottles were then loosely sealed and gently agitated for in excess of 16 hours. The resultant solvent extract, containing the extracted fats and PCBs was reduced in volume for clean up. Fat contents were determined by a similar manner, by reducing the extract to dryness and determining the residue gravimetrically. Extracts were purified by 'combination columns' containing alternate layers of acidified and basic silica gel, separated by neutral gel and topped with a layer of anhydrous sodium sulphate. The PCBs were eluted with n-hexane and extracts were analysed by injection in the splitless mode onto a J&W DB5-ms column directly coupled to the ion source of a VG AutoSpec Ultima or a VG 70SE. The average molecular ion response, calculated as the average response of the standards of each group, was used to quantify the PCBs of each chlorinated class and the total PCBs[5].

TEQ calculation: Toxicity of dioxin-like PCBs was converted into TCDD-equivalents of toxicity (TEQs) using the WHO system (1997). For each sample a total TEQ value was calculated as the sum of the individual TEQs of the dioxin-like PCB congeners.

Statistical analysis. Groups were compared by Student's t-test for unpaired samples, with a StatView program (SAS Institute Inc., North Carolina, USA).

Results and Discussion

Table 1 reports concentrations of PCB congeners and total PCBs in salmon purchased in Belgium, Italy, Spain and Portugal. The mean±SD concentration of total PCBs in 40 samples was 33.9±17.9 ng/g wet weight. However, the levels in single samples were very variable (6-65 ng/g wet weight) and the fat content was one important factor of variability, with a significant correlation ($r=0.44$, $p<0.005$) with PCB concentrations. Still higher correlations were observed on analyzing separately samples purchased in Spain and Italy ($r=0.775$, $p<0.0001$) (Figure 1). Furthermore, salmon samples from Belgium had the lowest content for total (Table 1) and for dioxin-like PCBs (Table 2). Differences were significant and PCB levels in Italy, Spain and Portugal were 3-4 times higher than in Belgium.

The results of this study indicate two ways which might be worthwhile in reducing PCB exposure of the general population. First, salmon bought in Belgium had generally the lowest content for PCBs. Salmon, is not produced in none of the investigated countries, and is imported. The implication is that monitoring might be worthwhile in selecting less contaminated items, thus reducing PCB exposure of the general population. Second, PCBs are lipophilic and accumulate in animal fats, and we did in fact find that PCB levels were related to the fishis fat content. If this the case, raising - or selecting – salmon that are less fatty, or smaller, would also help limit consumer exposure to PCBs.

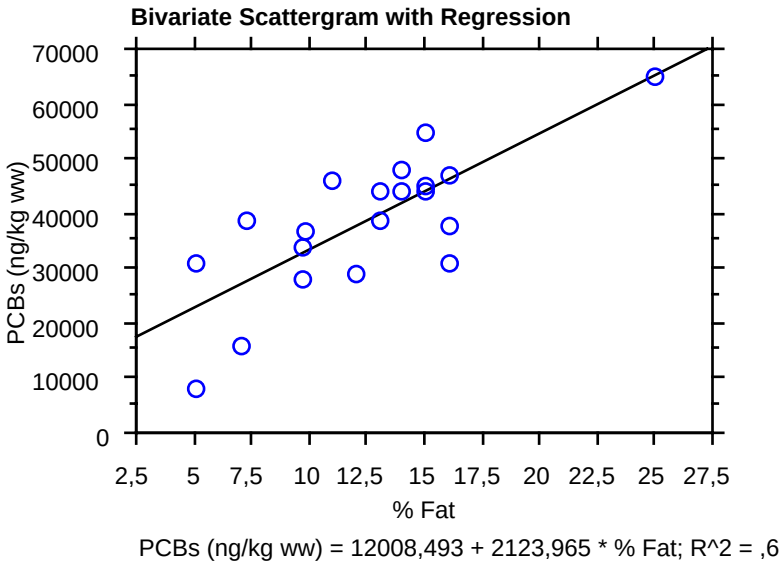

Figure 1. Relationship between fat content (%) and PCB concentrations (ng/kg of wet weight) in salmon purchased in Italy and Spain (cumulative analysis).

Table 1. Mean±SD of PCB congeners and total PCB concentrations (ng/kg wet weight) in salmon from Belgium, Italy, Spain and Portugal (each value n=10).

	Italy		**Belgium**		**Spain**		**Portugal**	
Congener n°	Mean (ng/kg)	SD	Mean (ng/kg)	SD	Mean (ng/kg)	SD	Mean (ng/kg)	SD
EC 7								
28	**309**	*54*	**108**	*39*	**256**	*121*	**411**	*329*
52	**808**	*131*	**335**	*225*	**849**	*325*	**1678**	*966*
101	**2050**	*467*	**766**	*352*	**2258**	*865*	**2800**	*672*
118**	**1786**	*388*	**729**	*323*	**1862**	*774*	**2310**	*498*
153	**5950**	*1733*	**1570**	*876*	**5710**	*2823*	**6170**	*2079*
138	**5080**	*1482*	**1565**	*823*	**4830**	*2251*	**5760**	*1826*
180	**4471**	*2287*	**497**	*248*	**1995**	*1114*	**1886**	*552*
Mono-ortho PCBs								
105	**582**	*110*	**282**	*117*	**586**	*232*	**845**	*224*
114	**180**	*569*	**ND**	-	**6**	*19*	**8**	*24*
118**	**1786**	*388*	**729**	*323*	**1862**	*774*	**2310**	*498*
123	**ND**	-	**ND**	-	**ND**	-	**ND**	-
156	**129**	*35*	**58**	*36*	**122**	*53*	**121**	*72*
157	**22**	*47*	**0**	*0*	**12**	*24*	**18**	*30*
167	**81**	*46*	**29**	*39*	**97**	*42*	**130**	*38*
189	**ND**	-	**ND**	-	**ND**	-	**ND**	-
Non-ortho PCBs								
81	**ND**	-	**ND**	-	**ND**	-	**ND**	-
77	**ND**	-	**ND**	-	**6**	*19*	**12**	*25*
126	**ND**	-	**ND**	-	**ND**	-	**ND**	-
169	**ND**	-	**ND**	-	**ND**	-	**ND**	-
Trichloro PCBs*	**725**	*111*	**261**	*103*	**553**	*167*	**1600**	*945*
Tetrachloro PCBs*	**2820**	*630*	**1056**	*442*	**3098**	*1027*	**5320**	*1980*
Pentachloro PCBs*	**5930**	*1418*	**2100**	*854*	**6280**	*1936*	**7280**	*2479*
Hexachloro PCBs*	**5560**	*1382*	**1666**	*806*	**6000**	*2743*	**7120**	*2350*
Heptachloro PCBs*	**4805**	*2292*	**397**	*135*	**2701**	*1344*	**5510**	*1817*
Total PCBs	**40400**	*10967*	**10910**[a]	*53848*	**36440**	*14582*	**47800**	*13071*

- * EC 7 are not included in the total result for each degree of chlorination
- **Congener 118 is reported either in EC 7 and in Mono-ortho PCBs
- ND is <50 ng/kg
- a, $p<0.001$ versus other countries

Table 2. Mean ±SD of TCDD-like toxic equivalents (WHO-TEQs, 1997) ascribable to dioxin-like PCBs (ng/kg wet weight) in salmon from Belgium, Italy, Spain and Portugal (each value n=10).

		Italy		**Belgium**		**Spain**		**Portugal**	
Congener n°	TEF	Mean (ng/kg)	*SD*	Mean (ng/kg)	***SD***	Mean (ng/kg)	***SD***	Mean (ng/kg)	***SD***
Mono-ortho PCBs									
105	0,0001	**0,058**	*0,011*	**0,028**	*0,012*	**0,059**	*0,023*	**0,085**	*0,022*
114	0,0005	**0,090**	*0,285*	**0**	*0*	**0,003**	*0,010*	**0,004**	*0,012*
118	0,0001	**0,179**	*0,039*	**0,073**	*0,032*	**0,186**	*0,077*	**0,231**	*0,050*
123	0,0001	**0**	-	**0**	-	**0**	-	**0**	-
156	0,0005	**0,064**	*0,017*	**0,029**	*0,018*	**0,061**	*0,027*	**0,060**	*0,036*
157	0,0005	**0,011**	*0,023*	**0**	-	**0,006**	*0,012*	**0,009**	*0,015*
167	0,00001	**0,0008**	*0,0005*	**0,0003**	*0,0004*	**0,0010**	*0,0004*	**0,0013**	*0,0004*
189	0,0001	**0**	-	**0**	-	**0**	-	**0**	-
Non-ortho PCBs									
81	0,0001	**0**	-	**0**	-	**0**	-	**0**	-
77	0,0001	**0**	-	**0**	-	**0,0006**	*0,0019*	**0,0012**	*0,0025*
126	0,1000	**0**	-	**0**	-	**0**	-	**0**	-
169	0,0100	**0**	-	**0**	-	**0**	-	**0**	-
Total TEQs (lower bounds)		**0,40**	*0,30*	**0,13** [a]	*0,06*	**0,32**	*0,14*	**0,39**	*0,10*

- a, $p<0.001$ versus other countries
- Lower bounds, ND=0 LOD

References

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