Estimation Of Human Exposure To Dioxins In Fish From Developing Countries

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Introduction

For many years there has been regulatory promotion of the consumption of fish due to its nutritional benefits. Fish is known to have proteins of high biological value as well as certain minerals and vitamins. With oily fish additional health benefits are related to polyunsaturated fatty acids (PUFAs), especially essential omega-3 PUFAs. However, oily fish can be a major source of lipophilic contaminants entering the human food chain.[1-4] Thus while there is some evidence that regular oily fish consumption may reduce mortality from cardiovascular diseases, and possibly even cancer, there are some other health related issues regarding the presence of contaminants in fish particularly in highly contaminated areas such as the Baltic Sea[4].

A major aim of the European Commission (EC) funded International Co-operation with Developing countries (INCODEV) project is to improve the commercial usage of under-utilised fish species from developing countries. Where there are still fish stocks that are not over-exploited, these may provide potential for sustainable fish management. Other research within the project has confirmed the nutritional value of these species.[5] In accordance with European Union (EU) regulations, it is also important to assess the potential hazards associated with fish consumption. As part of this hazard assessment, analysis of PCDD/Fs was conducted for samples of goby and horse mackerel (Namibia), ribbon fish and big head (India), cat fish and mapanga (Kenya), scianidae and carangidae (Malaysia), and burrito and flying gurnard (Ghana). Sample details are provided in Table 1. Horse mackerel from the UK was also analysed for comparative purposes. These values are discussed with respect to estimated dietary intake assessment for local consumers of these fish.

Materials and methods

Edible fish from Africa (Kenya, Namibia, Ghana), Asia (India, Malaysia) and UK with variable fat contents ranging from 2-5 % were de-boned and filleted. The samples were freeze-dried to constant pressure using a Lyoscience LS40 freeze dryer (Severn Scientific, UK). The dry sample was ground to a fine powder and fortified with $^{13}C_{12}$-labelled analogues of the target compounds. Samples were exhaustively extracted using hexane/acetone (4:1 v/v) and then dichloromethane /hexane (30/70 v/v) using a Soxtec Avanti apparatus (Foss UK). The crude extract was dried to constant mass for gravimetric lipid determination and then cleaned up using adsorption chromatography to generate three fractions – PCDD/Fs, non-ortho-PCBs and ortho-PCBs. Each fraction was concentrated with additional labelled recovery check standards and submitted for HRGC/HRMS analysis. The methods used have been validated and applied successfully in international proficiency exercises on dioxins in food.[6-8]Data satisfied published acceptance criteria including those of Ambidge *et al.*,[9] and the European Commission (2002/69/EC). Upper and lower bound TEQ concentrations were calculated applying the human exposure TEFs of Van den Berg *et al.*[10]

Country	Fish	Size	Fat	Age
		(cm)	(%)	(months)
UK	Horse mackerel	50	5.1	10-12
Kenya	Mapanga	25-30	4.1	10-12
Kenya	Cat fish	50	3.58	10-12
Ghana	Flying Gurnard	18-23	3.9	10-12

Ghana	Burrito	20-23	3.54	10-12
Namibia	Horse mackerel	35-40	3.53	10-12
Namibia	Goby	30	2.23	10-12
Malaysia	Carangidae	20-21	2.09	10-12
Malaysia	Sciaenidae	25-26	2.87	24
India	Big head	20-25	3.08	10-12
India	Ribbon fish	100	3.6	10-12

Table 1: Sample details of fish analysed.

Results and Discussion

The WHO-TEQ contributions from individual PCDD/Fs are shown in Figures 1 and 2. The results are expressed on a whole weight (wwt) basis of the edible portion.

Different species of fish presented different profiles of PCDD/Fs. The highest individual contribution came from 1,2,3,7,8-PeCDD in horse mackerel (Namibia) and ribbon fish (India) at 0.04 and 0.03 pg/g wwt respectively. Although profiles were similar for sciaenidae and carangidae (Malaysia) and flying gurnard and burrito (Ghana), in general the congener profiles observed were independent of the region of sample origin. This could be explained by differences in body size and lipid content [3,11,12] as shown in Table 1. Samples with larger body size and lipid content generally showed higher concentrations of PCDD/Fs, such as ribbon fish, cat fish and horse mackerel.

Horse mackerel from the UK contained the highest concentrations of PCDD/Fs congeners. Fish from Europe are generally reported to contain higher PCDD/F levels because of higher environmental and feed burdens.[3,13,14]

A crude estimate of dietary exposure to PCDD/Fs was calculated using the above data and recent statistical data obtained from FAO Globefish on import, export and fish consumption per capita, for each country.[15] The FAO Globefish data was utilised in the absence of national dietary intake, consumption or food basket data for the African and Asian countries that are part of the INCODEV project. The results are summarised in Table 2.[15] Daily intake per capita of PCDD/Fs in fish was observed in the following descending order: carangidae (Malaysia) > sciaenidae (Malaysia) > burrito (Ghana) > horse mackerel (UK) > horse mackerel (Namibia), flying gurnard (Ghana)> ribbon fish (India) > goby (Namibia) > cat fish (Kenya) > mapanga (Kenya) > big head (India). Although research has noted that the consumption of fish and fish products is a significant source of human exposure to PCDD/Fs,[16] it is important to note that national diets vary widely, even within Europe. Interpretations in terms of more specific regional variations regarding exposure are even more limited because of the availability of only two species from each region (one from the UK). Nevertheless, the PCDD/F data from this study provide new information on PCDD/F levels in fish, and potential dietary exposure in fish-eating populations, for countries where little data are available.

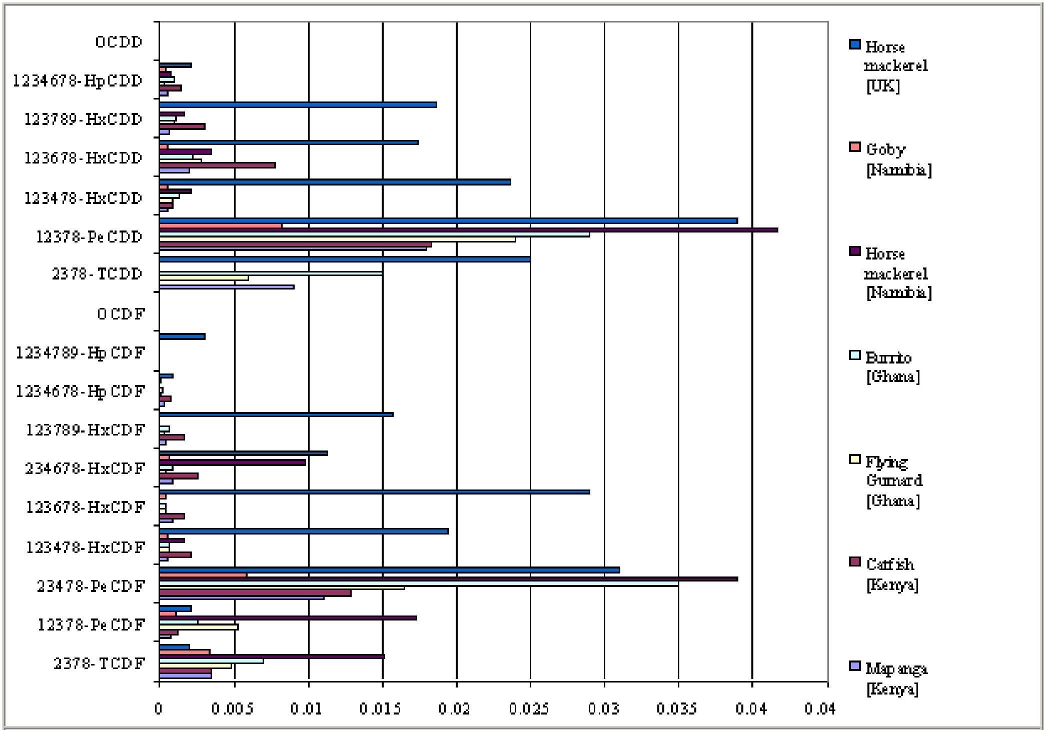

Figure 1: PCDD/F WHO-TEQ contributions in African Marine fish (pg/g wwt).

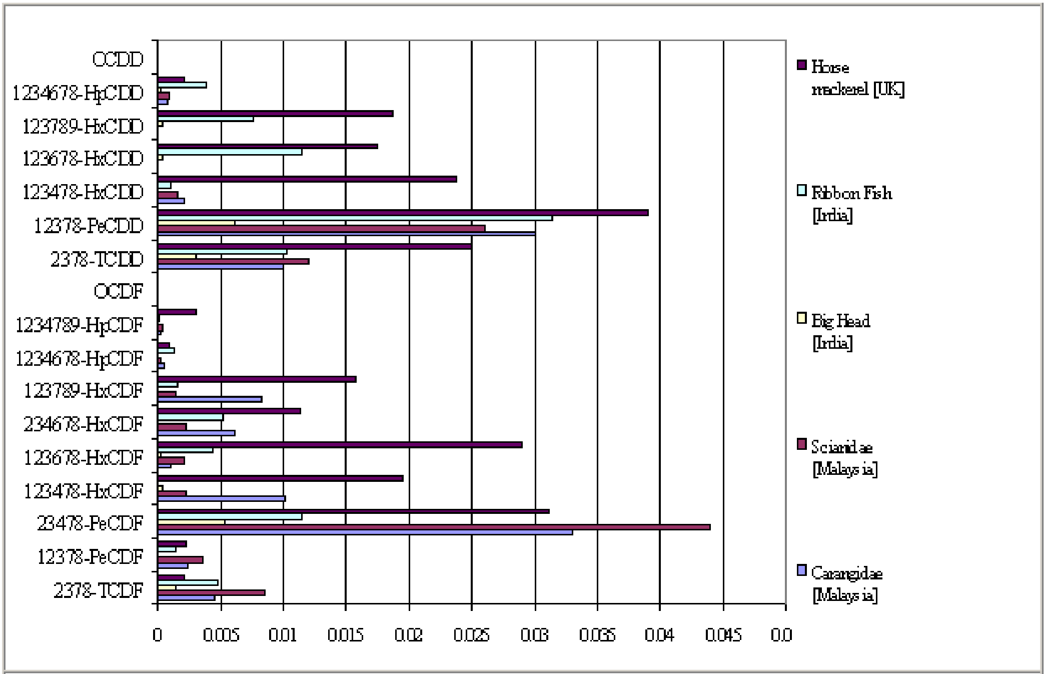

Figure 2: PCDD/Fs WHO-TEQ contributions in Asian Marine fish (pg/g wwt)

Fish	Country	Production	Imports	Exports	Food supply	Population (thousand)	Per capita supply (kg / year)	Consumption per capita per week (PCDD/Fs) [pg WHO-TEQ/ day]
Mapanga	Kenya	195455	16014	40537	170577	30535	5.6	0.013

Cat fish	Kenya	195455	16014	40537	170577	30535	5.6	0.015
Goby	Namibia	572542	49031	446644	26496	1892	14	0.017
Burrito	Ghana	468011	190380	76307	582065	19597	29.7	0.132
F. Gurnard	Ghana	468011	190380	76307	582065	19597	29.7	0.087
Big Head	India	5752231	5417	464602	4869167	1016831	4.8	0.005
Ribbon fish	India	5752231	5417	464602	4869167	1016831	4.8	0.022
Carangidae	Malaysia	1413601	421019	189455	1378545	22995	60	0.338
Scianidae	Malaysia	1413601	421019	189455	1378545	22995	60	0.294
H.mackerel	Namibia	572542	49031	446644	26496	1892	14	0.09
H.mackerel	UK	942893	1013880	759904	1190856	58906	20.2	0.13

Table 2: Summary of production, import, export and per capita supply of fish for Europe, Africa and Asia[15]. The consumption values (per capita) are calculated using the WHO-TEQs. The values for production, imports, exports and food supply are expressed as tonnes/ live weight.

Conclusion

Although limited, the data presented here indicate that fish from African and Asian marine waters contain PCDD/Fs at levels significantly below the limit of 1 to 4 ng WHO-TEQ/kg wwt[8] set by the European Commission. However a more comprehensive WHO-TEQ analysis should also include the dioxin-like PCBs. The concentrations measured were also much lower than levels reported in European fish of similar species and habitat [3,4,8]. Industrial growth in the developing countries may have contributed to a rise in the environmental levels of these contaminants, possibly explaining the slightly higher levels of PCDD/Fs in Malaysian compared to African fish. Concentrations of these contaminants depend upon the species of fish, geographical origin, age and other parameters. Further work is being carried out to monitor additional persistent organic pollutant residues in fish samples from the INCODEV project.

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