HUMAN EXPOSURE TO DIOXINS AND PCBs VIA FOOD IN BRAZIL: A ROUGH ESTIMATION AND DATA GAPS

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Introduction

Although present in every environmental compartment, the main source of human exposure to dioxins and PCBs is via ingestion of contaminated food[1]. Once released into the environment, these chemicals can reach even isolated locations through a phenomenon called global distillation[2]. Adsorbed in the organic particulate matter, these contaminants can be transferred to the sediment of oceans and rivers and to the top soil and plant leaves via atmospheric deposition[3]. The contaminated soil/plant is then ingested by small animals, bioaccumulating in the fatty tissues through the food chain and reaching human beings[1]. The World Health Organization estimates that more than 90 % of the human exposure of dioxins is via ingestion of contaminated food, wherein animal food products such as meat and dairy products are the principal source of intake[4].

Most industrialized (developed) countries have made extensive monitoring of these compounds in every media, but for most developing countries few data are available about the sources and the destination of dioxins and PCBs, especially regarding food contamination. Countries like the Netherlands, The UK and Germany have being monitoring the contamination of food by dioxin and dioxin-like compounds since early 1980s via their Total Diet Study (TDS) programmes[5,6]. These programmes are important to find trends in the concentration of POPs in the consumed food[7] thus helping the government in the revision of the limits and criteria for the produced or imported food. TDS programmes are also designed to assess the dietary intakes of chemicals and to evaluate whether actions has to be made to avoid public health problems[6]. Brazil only recently has released its inventory of sources for dioxin[8], but this kind of inventory does not include results for food. Some work has been done in environmental samples, such as sewage sludge[9], soil and milk samples from a contaminated area[10], compost samples[11] and more recently on ambient air[12]. Fewer data are available for food or feed samples, especially with respect to background levels, when there is no known contamination incident.

This work aims at roughly estimate the human exposure to dioxins and PCBs in Brazil via food consumption based on the published data. The Daily Intake (DI) is calculated and compared to the international regulations to assess whether the human exposure in Brazil is high and if the calculated DI is comparable to the other countries.

Materials and methods

An extensive search was made in the major databases (namely Periódicos CAPES, Web of Science, Scopus and Dioxin database on the Dioxin20XX website) to find published results on the determination of dioxins and dl-PCBs in food samples in Brazil. The search was made using the key words “Dioxin” and “Brazil” and all the papers reporting levels for dioxins and dl-PCBs in food were identified and included. Works done only on environmental samples or wild animals were excluded. The results were then compiled and the WHO-TEQ ($pg.g^{-1}$) obtained. The worst scenario (highest concentrations) was considered, as well as upper bond results (when the limit of detection was available). For the DI calculation, the ATSDR (Agency for Toxic Substances and Disease Registry, USA) approach was adopted[13].

Results and discussion

Based on the average per capita consumption of the identified classes of food present in the obtained papers[14] and on the average weight of adults and children[13], the DI for the Brazilian population was calculated as:

$$Daily\ Intake = \frac{C.IR.BF.EF}{BW}$$

In which:

C: is the concentration of the chemical contaminant (ug.kg^{-1}; ug.L^{-1}; ng.kg^{-1}; ng.L^{-1})

IR: is the intake rate (herein the per capita consumption in g.day^{-1})

BF: is the bioavailability factor, which is the amount of substance that is absorbed into a person's body after consumption (for screening proposes the bioavailability factor is typically assumed to be 1, which means all the amount of contaminant is absorbed in the body)

EF: exposure factor, which is how often a person is exposed to a contaminated medium (again, for screening proposes, the EF is assumed to be 1)

BW: is the body weight (in kilograms)

Table 1: Calculated Daily Intake (DI) for the Brazilian population (pg WHO-TEQ kg bw^{-1} day^{-1}).

Matrix type	Region	TEQ (pg/g fat)	Reference	IR (g/day)	EF	BF	BW-Adult (kg)	BW-Child (kg)	DI-Adult	DI-Child
Dioxins only										
Cheese	imported	0.01	Brooks et al, 2000	6.8	1	1	70	16	0.0001	0.004
Fish oil	imported	4.60		0.4	1	1	70	16	0.03	0.1
Cheese	imported	0.05		6.8	1	1	70	16	0.005	0.02
Cheese	imported	0.46		6.8	1	1	70	16	0.04	0.2
Chocolate	imported	0.04		3.5	1	1	70	16	0.002	0.009
Milk	imported	0.07		34.7	1	1	70	16	0.04	0.1
Cheese	imported	0.02		6.8	1	1	70	16	0.002	0.009
Tripes	imported	0.80		2.9	1	1	70	16	0.03	0.1
Cow´s milk	Cid Meninos, RJ	6.50	Braga and Krauss, 2000	34.7	1	1	70	16	3.2	**14.1**
Butter	RJ	0.30	Carvalhares et al, 2002	1.0	1	1	70	16	0.004	0.02
Cheese	RJ	1.30		6.8	1	1	70	16	0.1	0.5
Yogurt	RJ	2.80		9.8	1	1	70	16	0.4	1.7
Milk	RJ	0.13		34.7	1	1	70	16	0.06	0.3
Eggs	Cid Meninos, RJ	36284.90	Asmus et al, 2008	11.7	1	1	70	16	**6064**	**26533**
Milk	Not spec.	0.54	Rocha et al, 2013	34.7	1	1	70	16	0.3	1.2
Milk powder	MG	0.24	Papke and Tritscher, 2000	0.3	1	1	70	16	0.001	0.005
Infant Formula	SP	0.45		6.1	1	1	70	16	0.04	0.2
Dioxin and PCB´s										
Marine Catfish	Septiba Bay, RJ	0.66	Pereira, 2013	23.4	1	1	70	16	0.2	1
False herring fish	Septiba Bay, RJ	0.38		23.4	1	1	70	16	0.1	0.6
Chere-chere grunt fish	Septiba Bay, RJ	0.73		23.4	1	1	70	16	0.2	1072
Barracuda fish	Septiba Bay, RJ	1.50		23.4	1	1	70	16	0.5	2.2
PCB´s only										
Mussel	Arraial do Cabo, RJ	0.13	Galvão et al, 2012	0.7	1	1	70	16	0.001	0.006
Scallop	Arraial do Cabo, RJ	0.06		0.7	1	1	70	16	0.001	0.002
Mussel	Ganabara bay, RJ	0.57		0.7	1	1	70	16	0.006	0.02
Mussel	Septiba bay, RJ	0.39		0.7	1	1	70	16	0.004	0.02
Mussel	Ilha Grande bay, RJ	0.35		0.7	1	1	70	16	0.003	0.01
Scallop	Ilha Grande bay, RJ	0.02		0.7	1	1	70	16	0.0002	0.001
Crabs	Santos bay, SP	95.33	Magalhães et al, 2012	0.7	1	1	70	16	1	**4.2**
Fish	SP	81.00	Torres et al, 2010	23.4	1	1	70	16	**27**	**118.5**
	RJ	19.00		23.4	1	1	70	16	**6.3**	**27.8**
	PR	4.00		23.4	1	1	70	16	1.4	**5.8**
	MS	15.00		23.4	1	1	70	16	**5**	**21.9**
	AM	5.00		23.4	1	1	70	16	1.7	**7.3**
	PA	3.00		23.4	1	1	70	16	1	**4.4**
	RO	3.00		23.4	1	1	70	16	1	**4.4**

Table 1 shows the calculated DI as well as the source of the data input. Some alarming results can be seen about eggs and milk (in bold), with the DI overcoming the recommended daily intake of (1- 4) pg.kg $bw^{-1}.day^{-1}$ [25] by a factor of 1000 (Adults) and 6000 (Children) in the worst case. However, such results do not represent the DI for the majority of the population. The studies that came up with those significantly high concentrations of dioxin-like compounds were made in the same high contaminated area[16,18]. Regarding the fishes, the study made by Torres et al.[24] was conducted in some industrialized and very populated regions (SP, RJ, PR), in rivers that receive a considerable amount of sewage and another regions that have a historic use of pesticides for control of malaria disease (AM, MS).
Excluding the very high results, the DI calculated vary from (0.0002 - 1.671) pg TEQ.kg $bw^{-1}.day^{-1}$ for adults and (0.001 - 4.171) pg TEQ.kg $bw^{-1}.day^{-1}$ for children up to 6 years, which is comparable with the background DI of some industrialized countries such as the UK (DI (1.8 – 3.1) pg TEQ.kg $bw^{-1}.day^{-1}$), other European countries (DI (0.93 – 3.0) pg TEQ.kg $bw^{-1}.day^{-1}$) and the USA (DI (1.8 – 3.5) pg TEQ.kg $bw^{-1}.day^{-1}$) [26,27,28].
A great uncertainty can be attributed to this exposure estimation. Some matrices were analyzed only for dioxins and others only for PCBs (only one study showed results for both dioxins and PCBs), which make the calculated DI underestimated for those food types. Most studies covered only urban regions or places with a historic of contamination. Background levels are needed in order to make a good estimation of exposure in normal conditions. Besides, the lack of detailed information such as individual congener concentrations, base of the calculation (wet weight, fat weight, I-TEQ, WHO-TEQ), due to different approaches and objectives of the different studies, contributes to make any estimation a huge challenge.
For a more robust risk assessment, other parameters should be considered, such as the evaluation of contamination in other types of food that comprise the diet habits of the Brazilian population, the use of foods taken from places where there is no known history of contamination and a multiple foodstuff approach for the calculation of the DI (people do not eat a single type of food during the day) and the use of representative amount of data. To provide a better estimate of exposure for the Brazilian population, a Total Diet Study in accordance with international guidelines and applied in different regions may be a good approach to use.

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