Estimation of *per capita* intake of phosphorous flame retardants (PFRs) using Swedish market basket food samples

Giulia Poma[1*], **Anders Glynn[2]**, **Govindan Malarvannan[1]**, **Adrian Covaci[1]**, **Per Ola Darnerud[2]**

Universiteit Antwerpen

[1]Toxicological Center, University of Antwerp, Universiteitsplein 1, B-2610 Wilrijk, Belgium
[2]National Food Agency, P.O. Box 622, SE-75126 Uppsala, Sweden
[*]giulia.poma@uantwerpen.be

Livsmedelsverket
NATIONAL FOOD AGENCY, SWEDEN

INTRODUCTION and OBJECTIVES

- ✓ The ban worldwide of the main brominated flame retardants (BFRs), such as PBDEs and HBCDs, led to the increased usage of phosphorous flame retardants (PFRs) as alternatives[1].
- ✓ PFRs have been already measured in environmental abiotic matrices (air, dust, surface water, and sediments) all over the world[2,3].
- ✓ Data on the human exposure to PFRs from food are scarce.
- ✓ In this study, eight PFRs were analyzed in composite food samples (n=53) obtained from a recent Swedish Market Basket study in 2015, in order to contribute to a better knowledge about dietary intake of phosphorous flame retardants.
- ✓ Based on the results obtained and on the food consumption pattern in Sweden, the *per capita* intake of PFRs from food was estimated.

Compounds of interest

TDCIPP	Tris(1,3-dichloro-2-propyl) phosphate
TCIPP	Tris(1-chloro-2-propyl) phosphate
TCEP	Tris(2-chloroethyl) phosphate
TNBP	Tri-n-butyl phosphate
TEHP	Tris(2-ethylhexyl) phosphate
TPHP	Triphenyl phosphate
TBOEP	Tris(2-butoxyethyl) phosphate
EHDPHP	2-Ethylhexyl diphenyl phosphate

MATERIALS and METHODS

- ✓ The following food categories (n=13) were considered: cereals, pastries, meat, fish, fluid dairy products, solid dairy products, eggs, fats/oils, vegetables, fruits, potatoes, sugar/sweets, and beverages.
- ✓ The composite samples were lyophilized and homogenized.
- ✓ PFRs were extracted by solid-liquid extraction in 5 mL of acetonitrile, cleaned up through d-SPE and Florisil, and analyzed by GC-EI/MS.
- ✓ The *per capita* intake was determined by multiplying the *per capita* consumption of a specific food group with the concentration of the compound found in the considered food sample. Then, all the investigated food groups were added to give the total *per capita* intake.

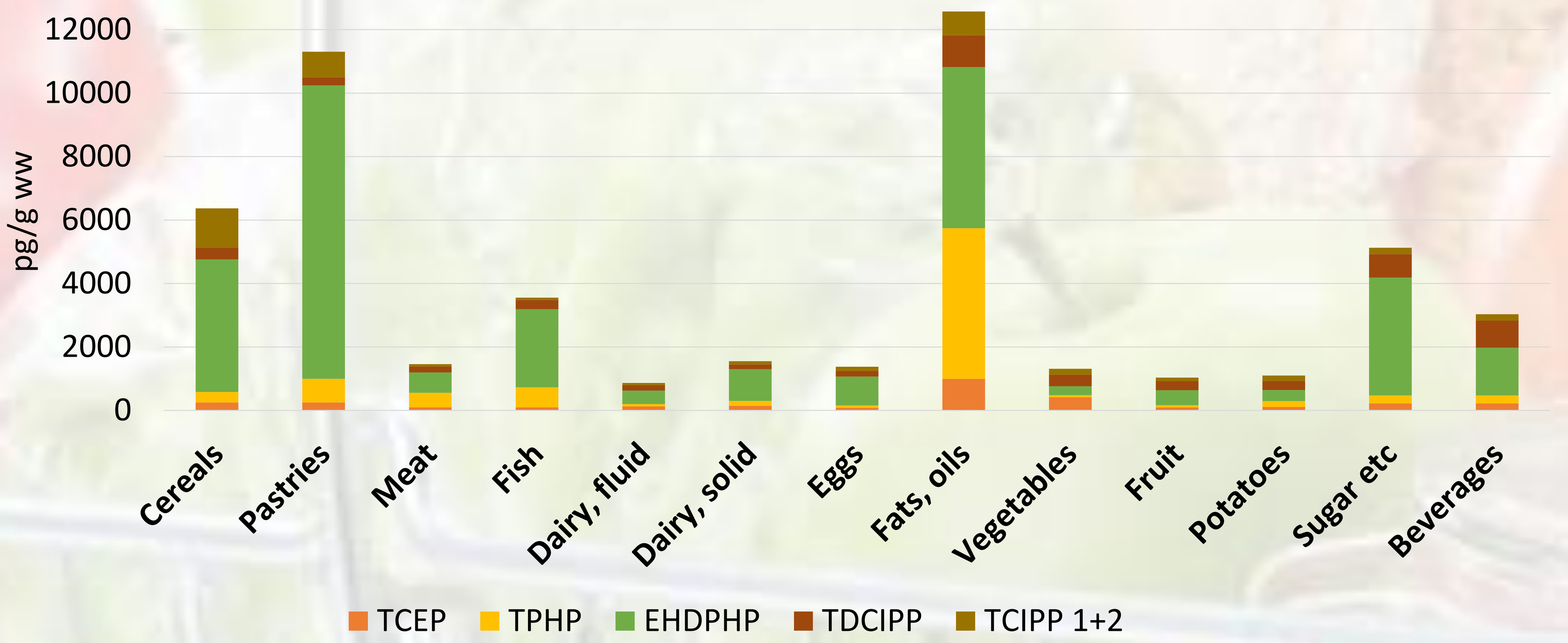

Fig. 1. Mean levels of PFRs in the different food categories based on the medium bound (MB) level

RESULTS and DISCUSSION

- ✓ TEHP, TBNP, TBOEP were < LOQ in all samples.
- ✓ Fig. 1 - Highest levels of PFRs were measured in cereals, pastries, fats/oils and sugar; EHDPHP showed the highest levels among the five PFRs.
- ✓ Table 1 - Contributions to the total intake: EHDPHP (57 %) > TDCIPP (14 %) > TPHP (11%) > TCIPP (10 %) > TCEP (7 %); cereals (26 %) > beverages (17 %) > sugar/sweets (11 %) > pastries (10 %).
- ✓ *per capita* intakes of PFRs from food were between 6 and 12 ng/kg bw/day, several orders of magnitude lower than the indicated reference dose values and representing from 0.01 to 0.3 % of the reported *RfD*.
- ✓ Fig. 2 - Estimated *per capita* intakes by adults of PFRs from food (total intake of 85 ng/kg bw/day for the sum of 5 PFRs) were generally higher than those estimated from dust, making the PFR exposure *via* diet equally or more important.

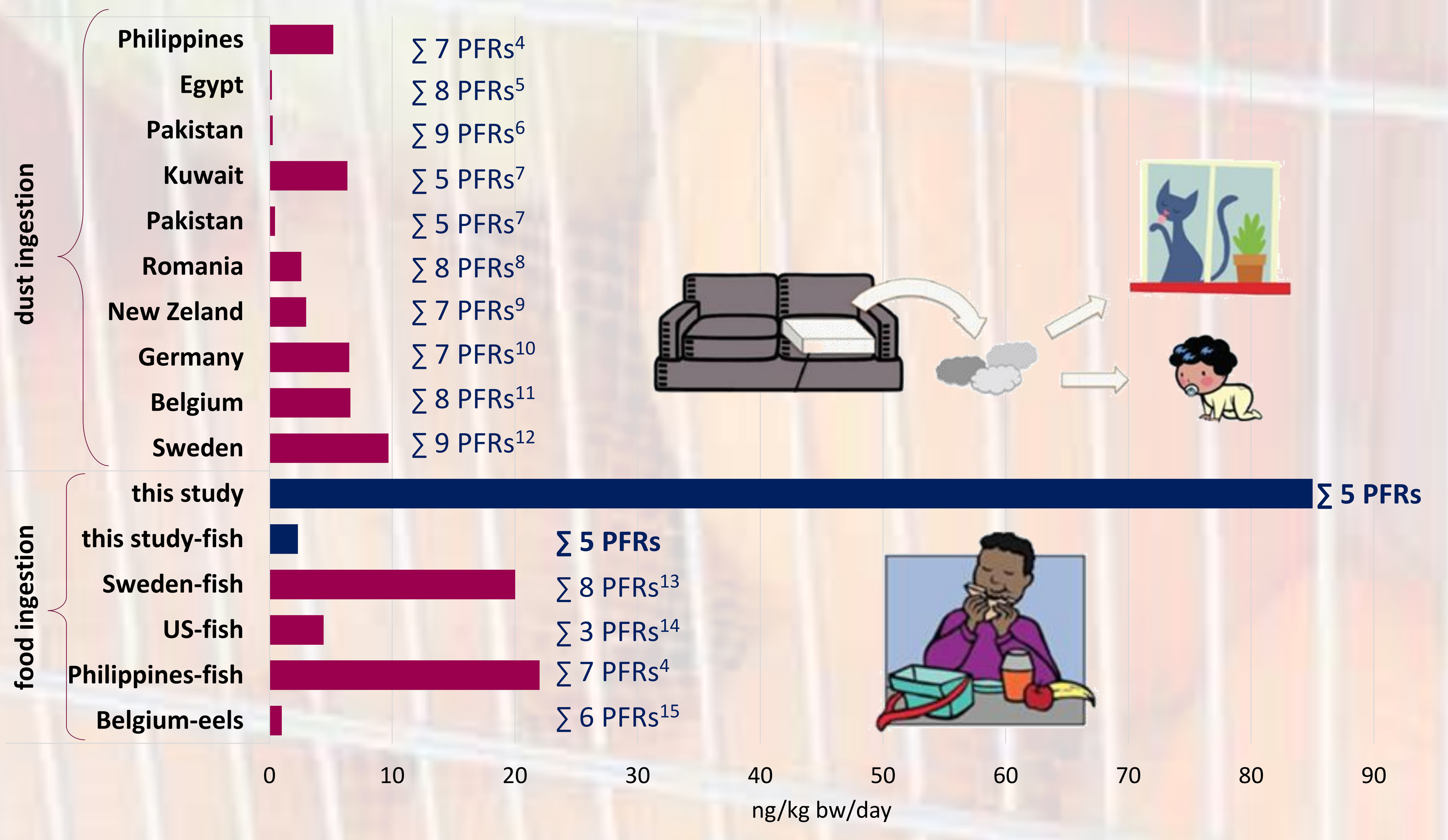

Fig. 2. Typical exposure to ∑PFRs via dust ingestion and maximum estimated exposure to ∑PFRs via food ingestion (ng/kg bw/day)

Table 1. *per ca*pita intake of individual PFRs from each food category based on MB levels (ng/day) and total intake considering all the food groups (ng/day and ng/kg bw/day). Reference dose (*RfD*) values (ng/kg bw/day) were calculated by dividing chronic NOAEL by a factor of 1000[9].

	TCEP	TPHP	EHDPHP	TDCIPP	TCIPP 1+2
RfD values (ng/kg bw/day)	*22,000*	*70,000*	*15,000§*	*15,000*	*80,000*
Cereals	57	77	955	87	282
Pastries	12	36	448	12	39
Meat	21	97	136	39	15
Fish	4	28	112	13	3
Dairy, fluid	41	24	137	56	20
Dairy, solid	11	11	79	11	7
Eggs	2	2	25	4	3
Fats, oils	44	213	228	44	33
Vegetables	81	13	55	72	36
Fruit	21	17	109	67	25
Potatoes	14	23	44	36	21
Sugar/sweets	28	31	466	92	25
Beverages	70	78	472	269	63
TOTAL (ng/day)	**406**	**650**	**3266**	**802**	**572**
TOTAL* (ng/kg bw/day)	**6**	**9.7**	**48.6**	**11.9**	**8.5**
% of RfD	*0.03*	*0.01*	*0.32*	*0.08*	*0.01*

*hypothetic population mean weight 67.2 kg; results calculated as MB (non-detects were replaced with ½*LOQ)
§European Commission IUCLID Dataset (2000): Value calculated by dividing chronic NOAEL by a factor of 1000 (http://esis.jrc.ec.europa.eu)

CONCLUSIONS

- ✓ Detectable levels of PFRs found in the majority of the 13 food categories. Highest PFR levels measured in cereals, pastries, fats/oils, and sugars/sweets. These categories were also the main contributors to the PFR *per capita* intake.
- ✓ The contamination due to PFRs during food industrial processing is possible.
- ✓ Human *per capita* exposure to PFRs from food was estimated and found much lower than the health-based reference points.
- ✓ Although lower levels of PFRs could be found in food than in dust, the exposure to PFRs *via* diet is equally important to the one *via* ingestion of indoor dust, as the food intake is comparably much higher.

ACKNOWLEDGEMENTS

The research leading to these results has received financial support from the Swedish Food Agency (SE) and from the University of Antwerp (BE).

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