BROMINATED FLAME RETARDANTS (BFRs) IN FOOD AND FOOD PRODUCTS AND IMPACT OF DIETARY INTAKE ON BODY BURDEN: POLICY IMPLICATIONS FOR REGULATING BFRs IN THE U.S.

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Background

In the U.S., serum concentrations of polybrominated diphenyl ethers (PBDEs) have been increasing[1] and are substantially higher in North America, overall, compared to Europe.[2,3] This is presumably due to the extensive use of flame retardants containing pentaBDE in consumer products sold throughout the U.S. and Canada,[4] and hence ingestion of PBDE-contaminated dust.[5-10] While a voluntary phase-out of penta, octa, and decaBDE use, a proposed amendment to the PBDE significant new use rule (SNUR) by the U.S. Environmental Protection Agency (USEPA), and state regulations and bans on certain consumer products containing PBDEs[11,12] are likely to considerably decrease human exposure to these chemicals from consumer products and dust over the longer term, there are no state or federal directives for regulating brominated flame retardants (BFRs) in food and food products on the U.S. market to reduce exposure via dietary intake. Here, the findings of several current U.S. studies evaluating concentrations of BFRs in different foods are assessed to better understand dietary intake and impact on body burden and the subsequent policy implications for regulating these compounds in food.

Materials and Methods

A literature survey was conducted to identify studies describing BFR concentrations in U.S. foodstuffs and estimated dietary intake. Articles published in English were identified by searching PubMed using various combinations of keywords and phrases. General internet searches and review of secondary references from published articles and annual indices of selected journals were also used to identify relevant studies.

Results

- The majority of research evaluating BFRs in U.S. foodstuffs has primarily estimated concentrations of PBDEs (Table 1)
  - Focus has been on a wide array of foodstuffs, ranging from market basket survey items, such as meat and dairy products, to wild-caught and farm-raised seafood
  - Approximately half of the studies measured deca-BDE in collected samples
  - Only three studies estimated contamination of food from BFRs other than PBDEs
  - None of the studies evaluated concentrations of tetrabromobisphenol-A (TBBPA), decabromodiphenyl ethane, and hexabromobenzene in foodstuffs
- Six studies estimated dietary intake of BFRs based on measured concentrations in food
  - Reported intake values of PBDEs presented all fell within the range of 0.02 to 20.0 ng/kg bw-d reported by Luksemburg et al.[13] for fish, beef and poultry

Results Cont'd

- Dietary intake of PBDEs was generally highest for meat, followed by dairy products/eggs, fish, and vegetable foodstuffs
- For HBCD, meat accounted for the largest portion of intake, but vegetables and fish contributed greater quantities than dairy and eggs

Conclusions

- Although results are often difficult to compare across studies due to differences in reporting styles, measured concentrations appear to vary considerably overall and within similar U.S. foodstuffs
- Multiple factors have hampered complete characterization of exposure to decaBDE from ingestion of food and food products
- Current evidence supports the idea that ingestion of PBDEs in dust and food both considerably influence U.S. body burdens;[5,7,8] yet, control of concentrations in food is likely more practicable than reducing indoor air and dust concentrations
- While the presence of BFRs in food products has not been explicitly addressed in U.S. legislative directives, there is potential for policy and regulatory actions to indirectly reduce exposure to PBDEs in food by decreasing use of these compounds or setting reference values for total exposure to PBDEs
- A useful next step in the regulatory decision making process would be the development of a health-based guidance value such as tolerable weekly intakes and/or residue and action levels for BFRs in meat, dairy and egg products, and fish by the appropriate federal and/or state agencies
  - More data must be collected on concentrations of all BFRs in U.S. food products, along with standardization of assumptions for estimating distributions of total dietary intake and impact on human body burden
  - Further research is also needed to identify and assess the influence of factors, such as uptake, metabolism and excretion, body fat content, and component causes affecting the mobilization of fat stores, on interindividual variability of body burden[14] and how these concentrations correlate with potential human health risks

Acknowledgments and References

References available upon request. The contents of this paper reflect the opinions and view of the authors and do not represent the official views of the U.S. NIH. The mention of trade names or commercial products does not constitute endorsement or recommendation for use.

Table 1 : Summary of U.S. Studies Describing BFR Concentrations in Foodstuffs and Estimated Dietary Intake

Food/Food Product	Collection Year	Location	Sample N	Chemicals/Congeners	Range of Total Concentrations	Dietary Intake	Reference
Freshwater Fish	1998-1999	Roanoke and Dan River watershed, VA	332	BDE-47,49,99,100,153,154	ND-47,900 mg/kg lipid	Not Reported	Hale et al. 2001
Salmon	1996	Lake Michigan, MI/WI	21	BDE-47,66,99,100,153,154	773-8120 ng/g lipid	Not Reported	Manchester-Neesvig et al. 2001
Freshwater Fish	1994-1999	Washington	16	BDE-47,99,100,153,154	1.4-1250 mg/kg	Not Reported	Johnson and Olson 2001
Chicken	1997	Arkansas, Texas, North Dakota	13	BDE-17/25,33,47,66,100,99,154,85,153,140,138,183, 209; one hexa-BDE, one octa-BDE, two nona-BDEs	1.93-45.7 ng/g lipid	Not Reported	Huwe et al. 2002
Lake Trout, Walleye	1980-2000	Great Lakes	35	BDE-17,28,47,49,66,71,85,99,100,138,153,154,183, 190,209; PBB-153	6.33-1395 ng/g lipid 3.90-92.4 ng/g lipid	Not Reported	Zhu and Hites 2004
Meat, Seafood, Dairy, Vegetable	2003	Dallas, TX	32	BDE-17,28,47,66,77,85,99,100,138,153,154,183,209	ND-3078 pg/g	Not Reported	Schecter et al. 2004
Fish, Meat	2003-2004	Sacramento and El Dorado Hills, CA	35	31 BDEs	85-4955 pg/g	0.02-20.0 ng/kg-d	Luksemburg et al. 2004
Saltwater Fish	2004	Coastal waters of Florida	38	BDE-28,47,66,85,99,100,138,153,154,183,203,209	1.8-306 ng/g lipid	Not Reported	Johnson-Restrepo 2005
Meat	2001	Brooksville, FL; Richmond, VA; Storrs, CT; State College, PA; Fargo, ND, Miles City, MT; Corvallis, OR; Las Cruces, NM; Tucson, AZ	65	BDE-28/33,47,85,99,100,153, 154,183	ND-16,620 pg/g lipid	0.3-0.8 ng/kg-d	Huwe and Larsen 2005
Fish	2001	San Francisco Bay; California coastline	43	BDE-47,99,100,153,154	13.3-1024 ng/g lipid	Not Reported	Brown et al. 2006
Meat, Seafood, Dairy	2003-2004	Dallas, TX	62	BDE-17,28,47,66,77,85,99,100,138,153,154,183,209	7.91-3726 pg/g	0.9-2.65 ng/kg-d	Schecter et al. 2006
Fish	2001, 2003, 2004	Maryland, Washington D.C., North Carolina	22	BDE-28,47,49,100,99,153, 154	0.04-38 ng/g	Not Reported	Hayward et al. 2007
Catfish	2006	Southern Mississippi	61	BDE-1,2,3,7,8,10,11,12,13,15,17,25,28,32,33,35,37, 30,47, 49,66,71,75,77,85,99,100,116,119,126,138, 153,154,155,156,166, 181,183, 190,197,203,207,209	3.6-4732 ng/g lipid	0.17-1.05 ng/kg-d	Staskal et al. 2008
Meat, Seafood, Dairy, Vegetable	2008	Los Angeles, CA; Dallas, TX; Albany, NY	90	BDE-28,47,49,66,85,99,100,138,153,154,183,203,209	36-3156 pg/g	0.81-2.67 ng/kg-d	Schecter et al. 2010
Meat, Fish, Dairy, Vegetable	2009	Dallas, TX	310	BDE-17,28,47,49,66,85,99,100, 119,126,138, 153,154,156,183, 196,197,206,207,209 HBCD	ND-6180 pg/g ND-593 pg/g	0.72 ng/kg-d* 0.22 ng/kg-d*	Schecter et al. 2010
Walleye	2010	Minnesota	10	BDE-17,47,49,66,85,99,100,153, 154,183/176	4.28-72.5 pg/g lipid	Not Reported	Scott et al. 2010
Meat	2002-2003 2007-2008	40 states of the U.S.	53	BDE-28,47,99,100,153,154,183	0.10-9.82 pg/g lipid	Not Reported	Huwe and West 2011
Meat, Fish, Peanut Butter	2009-2010	Dallas, TX	46	α,β,γ-HBCD	ND-1.3 ng/g	Not Reported	Schecter et al.

*Based on body mass of 70 kg