EXPOSURE TO BISPHENOL A (BPA) FROM FRESH , FROZEN AND CANNED FOOD FORM DALLAS, TEXAS, U.S.A.

Schecter A*[1], Lorber M.[2], Paepke O.[3], Shropshire W.[1], Christensen K[2], Gill, J.[1], Birnbaum, L.[4]

1.* University of Texas School of Public Health, Dallas Texas, USA; 2. Office of Research and Development, US Environmental Protection Agency, Washington, DC, USA; 3. Eurofins Laboratory, Hamburg, Germany; 4. NCI/NIEHS/NIH, RTP, NC, USA

Introduction:

Worldwide production of BPA is over six billion pounds per year.[1] BPA is used in the production of polycarbonates for hard plastics in common household items such as baby bottles, food products, toys, medical devices and epoxy resins for can liners.[1] There is evidence that food may be the main source of human exposure,[1] however, dust,[3] paper money,[4] soil,[5] and thermal paper[6] can be contaminated with BPA thus perhaps being potential sources for exposure.

BPA has been measured in blood,[7] urine,[2, 8] saliva,[9] and breast milk[10]; urine is typically the matrix of choice to characterize BPA exposure in humans.[2,8] The 2003/2004 cycle of the U.S. National Health and Nutrition Examination Survey (NHANES) reported BPA in urine in most Americans. (http://www.cdc.gov/nchs/nhanes.htm). This is especially of concern because of associations with adverse health effects of BPA found in animal models (e.g. endocrine disruption)[11] and some epidemiological studies (e.g. reproductive and developmental effects)[12]

In an earlier BPA in US food study, we measured BPA in canned, fresh, and frozen foods purchased from supermarkets in Dallas, Texas.[13] Here we report data that expands from our first study by adding a larger assortment of foods that came from supermarkets in Dallas, TX. The objective of our study was to estimate the general U.S. adult population exposures to BPA in food by combining the first round of data collection with data obtained in this current round and compare our forward-intake estimates with NHANES urinary BPA measurements. We also compare our food data and intake estimates with other published studies to look for similarities and differences among published research of BPA in foodstuffs.

Materials and Methods:

In the latest sampling, we purchased 116 individual food samples (fresh, frozen, and canned foods) from Dallas supermarkets in August, 2010. We included this new data with 88 of 105 analyses from our first study to have a combined set of 204 samples to be used in our analyses of dietary exposures.

An isotope dilution procedure was used for measurement of BPA in food. QC/QA measures included a five point calibration curve, re-calibration within each sequence of analysis (with a minimum of one blank in each batch of up to 10 samples), and duplicate analyses of >50 % of positive samples. Duplicate results matched in >90 % of cases. When duplicates did not match, a third analysis was performed. Reported concentration measurements are the arithmetic mean values of the matched results.

A “forward” approach estimating BPA food intake combines information on concentrations with amount of food ingested daily to arrive at an estimated daily intake from food. These were compared with intakes determined using a reverse dosimetry, or “backward” approach which relied on measurement of urine BPA and then back-calculates the intake that would be necessary to have resulted in this measurement.

Results and Conclusion:

Our most recent sampling of foodstuffs found 31 out of 116 samples (27%) were positive for BPA. When comparing canned vs non-canned food items, 26 of 37 canned samples (70%) were positive for BPA in contrast to only 5 of 79 non-canned foods (6%) with detected amounts of BPA. The lowest concentration was measured in a fresh peach (0.24 ng/g ww) while canned green beans had the highest measured concentration (149.0 ng/g ww). Canned vegetables had the highest mean concentration of the food categories (32.5 ng/g ww) followed by canned meat (1.5 ng/g ww), then canned fruit and fish (< 1 ng/g ww). There were five positive non-canned foods containing detectable levels included vegetable juice, two samples of fresh green beans, one sample of frozen mixed vegetables, and a fresh peach. Canned cut green beans had highest levels, (149 ng/g ww) followed by canned corn (121 ng/g ww) and canned mixed vegetables (81 ng/g ww). These values are slightly higher but consistent with results of our previous studies where cut green beans showed the highest level of BPA.[13] The combined data from both studies had 204 samples, 92 samples of frozen and fresh foods and 112 samples of canned foods. BPA was detected in 73% of canned foods and only in 7% of fresh and frozen foods. A comparison of data from our combined data set with other data from around the world is shown in Table 1.

Calculated adult food ingestion showed that canned food contributed 98% of total daily average intake; specifically, 12.4 of the daily total average intake of12.6 ng/kg-day came from canned foods. Canned vegetables accounted for 11.9 ng/kg-day and canned meat 0.4 ng/kg-day. These intake values are lower than those estimated from NHANES urine measurements, which ranged from 30 to 70 ng/kg-day. This range considered different NHANES cycles, ages, and other factors, but were all median values for the different permutations. There may be several explanations for the discrepancy between our forward based estimate intake and the NHANES urinary BPA "reverse dosimetry" approach. One reason may be that our food data is not representative of US food BPA concentrations. Differences in analytical methodologies used by laboratories that measure BPA could also explain the differences in measurements. Another reason may be that our survey did not include canned carbonated and non-carbonated, alcoholic and nonalcoholic beverages which were measured in other surveys such as in the European Food Safety Authority BPA exposure assessment[2]. This European assessment also provided intake estimates for non-food pathways, which we didn't consider, including thermal paper (shopping receipts, credit card receipts, etc.) at 18 ng/kg-day, cosmetics at 1.2 ng/kg-day, indoor air at 0.7 ng/kg-day, and dust (mostly ingestion) at 0.1 ng/kg-day.[2]

This study suggests that further research is needed to understand the extent of exposure to BPA by dietary and non-dietary pathways and to better characterize U.S. BPA exposure from foods and other sources.

Table 1. Comparison of canned food concentrations of BPA found in this assessment with others[1]

(This study and other studies, by category (all means calculated assuming ND = 0 except the EFSA data; n = total number of samples in data set)

Food Category	Data from this study		Data from other studies		Location and Specific Foods
	% Pos (n)	Mean ng/g ww	% Pos (n)	Mean ng/g ww	
Vegetables	92 (39)	20	100 (6)	23	Canadian[16], beans, beets, peas, tomatoes
			82 (73)	22	Europe[2] ; unspecified
			65 (17)	12	New Zealand[14], tomatoes, corn, beetroot, peas
			96 (25)	88	USA[15] green beans, corn, tomatoes, peas, misc. Veg (wax beans, spinach, stir fry, oyster mushrooms,
			92 (12)	31	USA[4] green beans, carrots, tomatoes, tomato paste, mushrooms, kidney beans, potatoes, olives
			100 (10)	37	Belgium[17]; carrots, corn, tomatoes, bamboo, mushrooms, olives; 2 veg soups included
Fruit	22 (9)	0.3	50 (4)	1	Canadian[16], cherries, pineapple
			79 (14)	12	Europe[2]; unspecified
			0 (16)	ND	New Zealand[14], apricots, peaches, pineapple, fruit salad
			57 (14)	5	USA[15], fruit cocktail, pineapple, sliced peaches
			100 (3)	3	USA[4], mandarin orange, pear, pineapple

			100 (4)	12	Belgium[17]; fruit mix, peaches, pears, applesauce
Meat	82 (38)	2	100 (1)	10	Canadian[16], luncheon meats
			62 (16)	64	Europe[2]; unspecified
			33 (6)	21	New Zealand[14], meat unspecified
			100 (17)	58	USA[15], pork & beans, chili
			100 (5)	3	USA[4], chicken (breast, sausages), ham
			100 (2)	26	Belgium[17]; chicken soup, sausages, ravioli which may have been partially meat not included
Fish	58 (12)	1	100 (1)	106	Canadian[16], unspecified
			66 (67)	33	Europe[2]; unspecified
			50 (8)	23	New Zealand[14], salmon, tuna
			100 (6)	12	USA[15], tuna, albacore, mackerel
			88 (8)	7	USA[4], sardines, clams, tuna, unspecified
			100 (4)	75	Belgium[17]; 2 tuna samples same brand at 169 and 126 ng/g, salmon and anchovy low at 3.6 and 0.9
Dairy	0 (8)	ND	100 (1)	15	Canadian[16]; evaporated milk
			100 (3)	20	Europe[2]; unspecified
Fruit/Vegetable Juice	100 (6)	0.6	50 (4)	0.2	Canadian[16]; vegetable, apple, citrus
			0 (2)	ND	USA[4]; orange, grape
			100 (4)	3	Belgium[17]; apple, orange, vegetable, tropical juice

References

1. Vandenberg, L. N.; Hauser, R.; Marcus, M.; Olea, N.; Welshons, W. V. Human exposure to bisphenol A (BPA). *Reproductive Toxicology* **2007**, 24 (2), 139-177.
2. *DRAFT Scientific Opinion on the risks to public health related to the presence of bisphenol A (BPA) in foodstuffs – Part: exposure assessment. EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (CEF)*; European Food Safety Authority: 2013; http://www.efsa.europa.eu/en/consultations/call/130725.pdf
3. Loganathan, S.N.; Kannan, K. Occurrence of Bisphenol A in Indoor Dust from Two Locations in the Eastern United States and Implications for Human Exposures. *Arch Environ Contam Toxicol* **2011**, 61:68–73.
4. Liao C.; Liu F.; Kannan K. Bisphenol S, a New Bisphenol Analogue, in Paper Products and Currency Bills and Its Association with Bisphenol A Residues. *Environ. Sci. Technol.* **2012**, 46: 6515–6522.
5. Xu, J.; Wu, L.; Chen, W.; Chang, A. C. Simultaneous determination of pharmaceuticals, endocrine disrupting compounds and hormone in soils by gas chromatography-mass spectrometry. *Journal of Chromatography A* **2008**, 1202 (2), 189-195.
6. Biedermann, S.; Tschudin, P.; Grob, K. Transfer of bisphenol A from thermal printer paper to the skin. *Analytical and Bioanalytical Chemistry* **2010**, 398 (1), 571-576.
7. Cobellis, L.; Colacurci, N.; Trabucco, E.; Carpentiero, C.; Grumetto, L. Measurement of bisphenol A and bisphenol B levels in human blood sera from healthy and endometriotic women. *Biomedical Chromatography* **2009**, 23 (11), 1186-1190.
8. *Fourth National Report on Human Exposure to Environmental Chemicals*; Department of Health and Human Services: Centers for Disease Control and Prevention, National Center for Environmental Health: Atlanta, Georgia. 2009; http://www.cdc.gov/exposurereport/
9. Zimmerman-Downs, J.; Shuman, D.; Stull, S.; Ratzlaff, R. Bisphenol A blood and saliva levels prior to and after dental sealant placement in adults. *Journal of Dental Hygiene* **2010**, 84(3), 145-150.
10. Sun, Y.; Irie, M.; Kishikawa, N.; Wada, M.; Kuroda, N.; Nakashima, K. Determination of bisphenol A in human breast milk by HPLC with column-switching and fluorescence detection. *Biomedical Chromatography* **2004**, 18 (8), 501-507.

11. Moriyama K., Tagami T., Akamizu T., Usui T., Saijo M., Kanamoto N., Hataya Y., Shimatsu A., Kuzuya H., Nakao K. Thyroid hormone action is disrupted by bisphenol A as an antagonist. J Clin Endocrinol Metab. 2002 Nov;87(11):5185-90.
12. Rochester, Johanna R. Bisphenol A and human health: A review of the literature. *Reproductive Toxicology* **2013**, 42, 132-155
13. Schecter, A.; Malik, N.; Haffner, D.; Smith, S.; Harris, T. R.; Paepke, O.; Birnbaum, L. Bisphenol A (BPA) in U.S. Food. *Environmental Science & Technology* **2010**, 44 (24), 9425-9430.
14. Thomson, B.M.; Grounds, P.R. Bisphenol A in canned foods in New Zealand: An exposure assessment, *Food Additives and Contaminants* **2005**, 22: 65-72.
15. Noonan, G.O.; Ackerman L.K.; Begley, T.H. Concentration of Bisphenol A in Highly Consumed Canned Foods on the U.S. Market. *J. Agric. Food Chem.* **2011**, 59: 7178–7185.
16. Cao, X.L.; Perez-Locas, C.; Dufresne, G.; Clement, G.; Popovic, S.; Beraldin, F.; Dabeka, R.W.; Feeley M. Concentrations of bisphenol A in the composite food samples from the 2008 Canadian total diet study in Quebec City and dietary intake estimates. *Food Additives & Contaminants: Part A* **2011**, 28:6, 791-798.
17. Geens, T.; Apelbaum, T.Z.; Goeyens, L.; Neels, H.; and Covaci, A. Intake of bisphenol A from canned beverages and foods on the Belgian market. *Food Additives and Contaminants* **2010**, 27, 1627-1637.