PHENOLIC SUBSTANCES IN FOOD – ANALYTICAL SURVEY OF 11 PHENOLS, INCLUDING BPA, AND ESTIMATED INTAKE BASED ON SWEDISH MARKET BASKET SAMPLES

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Introduction

Phenolic substances present in food are not commonly analysed, and relatively few results are found in scientific literature. One exception is bisphenol A (BPA), a recently much debated substance that could leak from plastics used in food contact materials and thus may be found in certain food items. Also, some phenols are used as food additives (BHT, BHA – antioxidants) and their presence in food is expected. However, other phenolic substances present in our environment may also end up in food, even if they are not directly used in food production and processing. In these cases, their presence in food could be a result of a contamination along the food distribution pathway, including food packaging materials. If we have little information on levels of phenolic compounds in our food, even less is known of possible health effects. We know that BPA is suspected be a hormone-disrupting chemical and that several brominated flame retardants are believed to exert some of their hormonal effects after metabolism to phenolic transformation products, but effects of other phenols are not much studied. In the present study, the aim is to estimate mean (per capita) intakes of phenolic compounds (n=11) from food, to investigate the relative contribution from different food groups to the total intake, and to compare intake levels of these phenols using 1999, 2005 and 2010 market basket studies, with the ambition to study possible trends.

Materials and methods

The food samples for analyses were taken from the sample bank of Market Basket samples at NFA, comprising samples obtained in 1999, 2005 and 2010. In short, homogenates of each food group (12 groups) were produced, and these were pools from all the grocery shops/chains included in the respective project round. In all, about 50 food samples were analysed. More information on the Swedish market basket studies are given in separate articles and report [1,2,3].

In the present project, the food samples, comprising different food matrices, were analysed for the following phenolic compounds: bisphenol A (BPA), 2,6-di-tert-butyl-4-metylfenol (BHA), 2,6-di-tert-butyl-4-metylfenol (BHT), 4-nonylphenol (4-NP), 4-tert-octylphenol (4-t-OP), 4-tert-butylphenol (4-t-BP), pentachlorophenol (PCP), triclosan (TC), 4-bromophenol (4-BrP), 2,4-dibromophenol (2,4-DBP) and 2,4,6-tribromophenol (TBP). Final analytical determination was made by GC-MS/MS, in MRM (multi reaction monitoring) mode in case of non-halogenated compounds, and in NCI (negative chemical ionization) mode in case of halogenated compounds. The analyses were performed at IVL (Swedish Environmental Research Institute) Stockholm.

Results

Data in Table 1 give the estimated per capita intake of the studied phenolic compounds, presented as the total intake by addition of all 12 groups present in the 2010 market basket study. The per capita consumption of these food groups, based on statistics from the Swedish Board of Agriculture, was multiplied with the phenolic compound level of the respective group. The resulting data show the population (per capita) average total intake of these compounds, and consequently neither the range in intake nor specific consumer groups could be studied with this method. Of the studied compounds, the estimated total intake was highest in case of 4-NP (15 500 ng/person/day; MB calculation), about three times the intake of the second highest, BHA, and six times the intake of BHT, 4-t-OP and BPA.

In order to give further information on the relative contribution of different food groups to the total intake of a specific compound the data could be visualized as staple diagrams in Figure 1. By studying these diagrams it is clearly shown that depending on studied compound, different food groups are major food contributors (e.g. BHA – fish; 4-NP – cereals and fats; PCP – cereals; BPA – vegetables).

The potential difference in intake levels over time was studied by comparing intake data from the market baskets from 1999, 2005 and 1010, based on MB levels (all samples analysed at the same lab, and at the same time) and presented for some of the compounds in Figure 2. Some changes are visible between sampling time points, but in general obvious trends are difficult to identify. (The marked elevation in estimated intake of BHA in 2005 may be due to occasionally high levels in single food items that have been included in the 2005 market basket study, but not at the other two time points).

Discussion

Using the market basket approach and the new analytical data on phenolic compounds, estimation of the population mean, per capita, intake for the average Swedish consumer could be performed. For many of the studied compounds estimation of total diet exposure for Swedish consumers was done for the first time. It should however be noted that due to the many analytical results below LOD, these estimations are only approximate. Consequently, depending on LB or UB levels the estimations, e.g. of intakes, performed on these data will vary to a certain extent, as shown in Table 1.

The estimated intake values could be used in risk evaluation against defined reference values for health effects. However, such reference values are rarely found for this type of phenolic compound, and may, to our knowledge, only be present in case of BPA. In this case our per capita intake estimation, based on 2010 market basket study, is 37 ng/kg bw/day; MB calc.). This could be compared to EFSA's recently recommended new temporary ADI of 5 microg/kg bw/day.

The above presentation has discussed levels of phenolic compounds one by one and compared intake levels with ADI or similar, when such reference levels are present. However, as we have shown in this report we are exposed to a number of exogenous phenolic compounds and there are of course many more exogenous phenolic compounds than those studied at present that could be found in food, and consequently also in our body,. Indeed, a Swedish study on blood donors showed that over 100 phenolic halogenated compounds (PHC) were analytically indicated in plasma, of which two major compounds were 2,4,6-tribromophenol (TBP) and pentachlorophenol (PCP) [4]. Consequently, we may have to give more interest in this group of compounds found in environment and in food, and learn more about their individual effects, but it is even more important to find out potential health consequences of their combinative effects (e.g. [5]).

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Table 1. Per capita intake of 11 phenols from food, based on 2010 Swedish food basket data and expressed as ng/person/day or (MB) as ng/kg bw/day (LB=lower bound; MB=medium bound; UB=upper bound; mean population body wt. in 2010 market basket study = 67.2 kg)

	4-BrP	4-t-BP	BHT	BHA	2,4-DBP	4-t-OP	4-NP	TBP	PCP	TC	BPA
LB	82.6	1002	2391	4886	19.3	0	13384	82,7	577	9.28	1807
MB	112	1153	2613	4925	43.7	2241	15502	103	611	116	2463
UB	141	1307	2838	4962	68.2	4982	17634	123	645	226	3313
MB/kg bw	1.67	17.2	38.9	73.3	0.65	33.3	231	1.53	0.09	1.73	36.7

Figure 1. Relative contribution from different food groups to the total intake of the 12 studied phenols (based on MB levels)

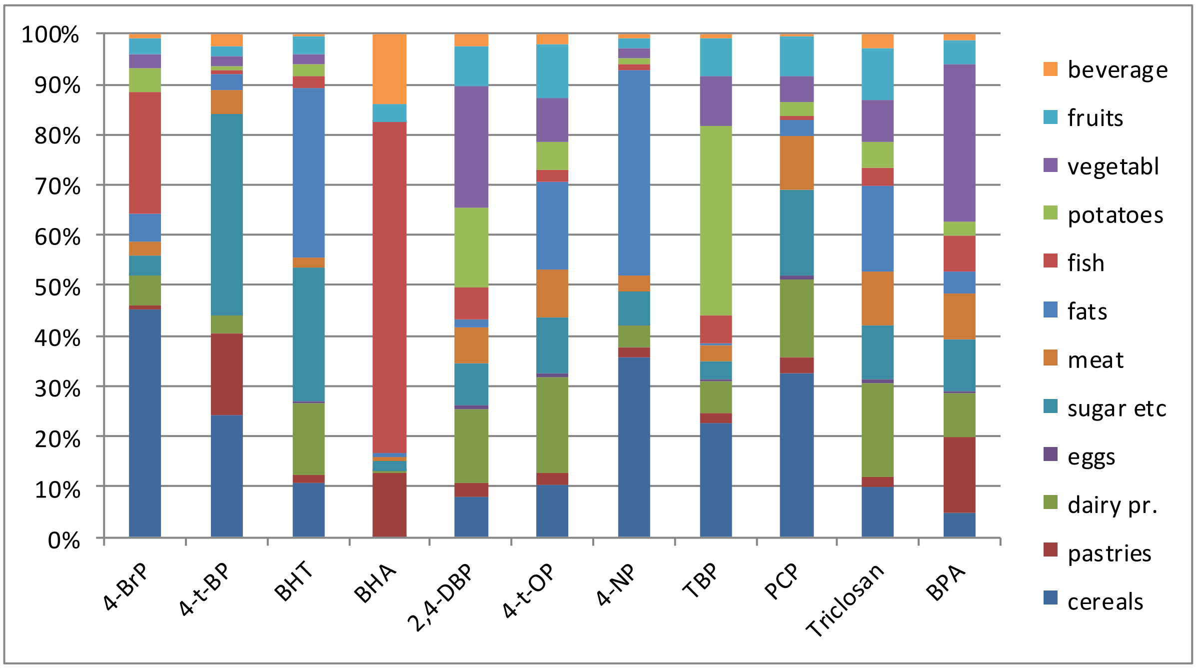

Figure 2. Changes in estimated intake over time for some of the studied phenols, based on market basket data from the years 1999, 2005 and 2010 (y-axis: ng/person/day; MB levels)