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Low intake of polycyclic aromatic hydrocarbons in Sweden: Results based on market basket data and a barbecue study

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ABSTRACT

In a market basket study made at the National Food Agency in Sweden, in which the most common consumed foodstuffs are sampled, the content of polycyclic aromatic hydrocarbons (PAH), benzo(a)pyrene (B(a)P) and PAH4 (B(a)P, chrysene, benzo(b)fluoranthene, and benz(a)anthracene) were analysed. To this data, results on B(a)P and PAH4 levels originating from a home-barbecue-study on sausages and loin of pork were added. The calculated total mean intake of B(a)P and PAH4 was 50 ng/person and day 276 ng/person and day, respectively. Sugar and sweets, cereal products, meat, and dairy products contributed most to the total intake. In case of PAH concentrations below LOD, 0.03 µg/kg, ½ LOD was used in the intake calculations. The highest mean level of B(a)P and PAH4 were found in the barbecued products, but since the estimated consumption in Sweden is low, the contribution to the total food intake is almost negligible, about 2%. The calculated B(a)P levels in food has decreased during the last 10 years and indicates a low cancer risk for the Swedish population.

1. Introduction

Polycyclic aromatic hydrocarbons (PAH) is a group of some hundreds of identified compounds which are produced during the incomplete combustion or pyrolysis of organic material. Many of these compounds are well studied and have also, by e.g. the WHO, been classified as genotoxic and possibly/probably carcinogenic to humans (IARC, 2010, WHO, 2005). The most studied PAH is Benzo(a)pyrene (B(a)P), classified as a human carcinogen, Group 1 (IARC, 2012). Thus it is urgent to keep the emission of these substances to the environment as low as possible. Therefore, it is positive that the emission of PAH from heating systems and traffic has decreased during the last half a century, which hopefully has led to lower concentration also in food. Furthermore, the improved process for refining vegetable oil with active carbon, which started some decades ago, has decreased PAH levels (Hopia et al., 1986).

When the concentration of contaminants is low, an increased sensitivity of the instrumentation used for analysis is required. This demand of high sensitivity has already resulted in about 10 times lower detection limit, LOD, for B(a)P in food, than in the beginning of the 1980s (Hopia et al., 1986; Wretling et al., 2010). There might be several explanations for a lower LOD; the use of new sensitive equipment is one. Another explanation is the established collaboration between European laboratories forcing a methodological development. Since 2006, workshops and inter-laboratory comparison tests have been organized by the European Union Reference Laboratory for PAH on a yearly basis.

Taking into consideration the abovementioned lowering of PAH, it is important to clarify whether these efforts are reflected also in lower intake levels among consumers.

In the calculations of the intake levels of contaminants, it is an advantage to avoid targeted samplings, i.e. data selected on foodstuffs which could have unusually high PAH levels. Using the data generated from an analysis of market baskets, this pitfall is eliminated.

At the Swedish National Food Agency, market basket surveys are recurrently performed, with the purpose of obtaining information on levels of nutrients and potentially harmful components, e.g. PAH in our food (NFA, 2012). Based on food consumption data, food baskets containing the most common foodstuffs, with a mean consumption of at least 0.5 kg per person and year, are purchased. These purchased foods correspond to approximately 90% (by weight) of the direct consumption in Sweden (SBA, 2010).

The content of B(a)P in food has been analysed during decades, and because of this it is possible to follow changes in levels over time, and to compare the obtained B(a)P concentrations and exposure levels. The aim of this study was to clarify the concentration of B(a)P and PAH4 (B(a)P, benzo[a]anthracene, benzo[b]fluoranthene, and chrysene) in the collected market baskets and thereby calculate the per capita intake of B(a)P and PAH4 via food in Sweden today. Furthermore, since barbecued food was not covered in the present market basket study, we have made an additional study on B(a)P and PAH4 and included these data in our intake calculations. Based on the calculated total intake of B(a)P, we have compared the result

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Table 1
Food groups used for sorting food items purchased in the market basket study of 2010. The presented figure of percentage is the contribution of each food group to the total annual per capita consumption, which was 745 kg/year. In total more than 130 different food items were purchased.

Group no.	Food group	Description of food items/categories[a]	Percentage of total per capita consumption
1	Cereal products	Flour, grain, corn flakes, pasta, bread	11
2	Pastries	Biscuits, buns, cakes, pizza	3
3	Meat products	Beef, pork, lamb, game, poultry, cured/processed meats	10
4	Fish products	Fresh and frozen, canned, shellfish	3
5	Dairy products	Milk, sour milk, yoghurt, cream, hard cheese, processed cheese, cottage cheese	21
6	Eggs	Fresh eggs	1
7	Fats	Butter, margarine, cooking oil, mayonnaise	2
8	Vegetables	Incl. root vegetables, fresh and frozen, canned products	9
9	Fruits	Fresh and frozen, canned products, juice, nuts, cordials, jam	12
10	Potatoes	Fresh, French fries, potato crisps, potato purée (ready-made)	6
11	Sugar and sweets	Sugar, honey, chocolate, sugar sweets, mustard, ketchup, dairy and vegetable fat-based ice-cream, ready-made sauces and dressings	6
12	Beverages	Soft drinks, mineral water, beer (up to 3.5 vol. % alcohol)	16

Note. [a]The proportion of the different food items in the food groups reflects, by the Swedish population, the actual purchase figures.

with earlier intake calculations and also estimated the mean cancer risk for the whole population.

2. Material and methods

2.1. The market basket study

2.1.1. Collection and preparation of food samples

In this market basket study the most consumed foodstuffs in Sweden were purchased and analysed. The choice of foodstuffs was based on per capita food consumption (SBA, 2010). For a detailed description of the sampling, see Darnerud et al. 2006, NFA 2012, Törnkvist et al. 2011. In short, the shopping was made in May–June in the year 2010 in the city of Uppsala, located in the middle of Sweden, in five different major grocery chains. This time the collection was restricted to one city, since earlier market basket studies did not show any significant differences in PAH levels in food sampled in different cities in Sweden. By using a specified shopping list containing the most purchased foodstuffs, the different market baskets were collected. From each of the five grocery stores, food representing both low-price and standard price (from one store, only standard price) were collected in different baskets, making a total of 9 different baskets. The food items in each of the purchased baskets were divided into 12 different food groups, e.g. cereal products, pastries, meat, etc., Table 1. The food groups were homogenized and stored in a freezer until analysed, making a total of 108 different homogenates. Concerning the analysis of PAH, the homogenates were mixed from different stores and we ended up with 11 low price homogenates and 12 standard price homogenates. The PAH levels in the food representing low price were very similar to the levels from the standard price, therefore only the data originating from one of these (the standard priced products) were used in the following intake calculations.

In case of food items where wastage is obvious, inedible parts such as bone, skin, peel etc., were removed prior to weighing. It should also be noted that no further preparation of the food, e.g. cooking and frying, was done before analysis.

The food groups, followed by the figure of the weight proportion (%) of each group are described in Table 1. Neither drinking tap water nor coffee or tea was included among the sampled food.

2.1.2. Analysis of food samples

PAH were analysed at the National Food Agency (NFA), Sweden, in accordance with a GC/MS method described elsewhere (Wretling et al., 2010). In the same time and in the same way as the samples from this study (collected in the year 2010), samples from an earlier market basket study (in 1999) were also analysed. The same methods of collection and preparation of food from the 1999 study were applied to the 2010 study. Briefly, samples from the food groups were spiked with perdeuterated PAH as internal standards and saponificated in methanolic KOH solution at 70 °C. The samples were subsequently extracted with cyclohexane and washed several times with a mixture of methanol and water. Thereafter, samples were cleaned-up on two sets of SPE columns and injected in an Agilent 6890 gas chromatograph connected to an Agilent 5975 mass selective detector. A 30 m DB-35 ms fused silica column was used for separation. This column can separate chrysene from triphenylene which is of great importance for the parameter PAH4. The analytical method complies with the criteria for official control of B(a)P according to the Commission Regulation (EC, 2007).

The method is accredited against ISO 17025 by SWEDAC for 25 PAH, including all 15 PAH analysed in this study. In this report we present only data from the four compounds that constituted PAH4 (B(a)P, benzo[a]anthracene, benzo[b]fluoranthene, and chrysene). The accuracy of the method and the performance is proven by using certified reference materials and participating in proficiency tests. Excellent z-scores all within ±2 were obtained for a number of PAH in different matrices like oils, fats, smoked meat, smoked fish, raw fish, infant formula, sausages, mussels, cacao butter, and liquid smoke.

For the daily quality control an in-house control sample, maize oil, is run with each batch of samples. From each homogenate, duplicates are analysed. The limit

Table 2
PAH levels (μg/kg) in food groups, originated from market basket studies made in Sweden in 2010 and 1999.

Food group	B(a)A 2010 (1999)	Chr 2010 (1999)	B(b)F 2010 (1999)	B(a)P 2010 (1999)	PAH4 2010 (1999)
Cereal products	0.03 (0.09)	0.04 (0.15)	0.04 (0.07)	0.03 (0.06)	0.14 (0.37)
Pastries	0.07 (0.52)	0.09 (0.64)	0.07 (0.23)	0.05 (0.22)	0.28 (1.61)
Meat	0.12 (0.12)	0.09 (0.10)	0.03 (0.04)	0.03 (0.04)	0.27 (0.30)
Fish	0.03 (n.a.)	0.03 (n.a.)	<0.03 (n.a.)	<0.03 (n.a.)	0.09 (n.a.)
Dairy products	<0.03 (n.a.)	<0.03 (n.a.)	<0.03 (n.a.)	<0.03 (n.a.)	0.06 (n.a.)
Eggs	<0.03 (n.a.)	0.03 (n.a.)	0.03 (n.a.)	<0.03 (n.a.)	0.09 (n.a.)
Fats	0.15 (0.21)	0.21 (0.29)	0.14 (0.15)	0.12 (0.13)	0.62 (0.78)
Vegetables	<0.03 (<0.03)	0.05 (<0.03)	<0.03 (<0.03)	<0.03 (<0.03)	0.09 (0.06)
Fruits	<0.03 (<0.03)	0.03 (0.07)	<0.03 (<0.03)	<0.03 (<0.03)	0.07 (0.11)
Potatoes	<0.03 (n.a.)	<0.03 (n.a.)	0.03 (n.a.)	<0.03 (n.a.)	0.07 (n.a.)
Sugar and sweets	0.14 (0.12)	0.18 (0.14)	0.13 (0.07)	0.10 (0.08)	0.55 (0.41)
Beverages	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

B(a)A = Benz(a)anthracene, Chr = Chrysene, B(b)F = Benz(b)fluoranthene, and B(a)P = Benz(a)pyrene. PAH4 = the sum of B(a)A, Chr, B(b)F, and B(a)P. Each figure is a mean of two parallel analyses. All levels below the detection limit, < 0.03 μg/kg, has been estimated as 0.015 μg/kg in the calculation of PAH4 and in the intake calculations. Since none of the analysed PAH (in total 15, data not presented here) in beverages did not show any sign of occurrence, the levels have been estimated to zero. Some of the food groups originated from 1999 were not analysed (n.a.) The reason was that they were considered to be of minor importance for the exposure to PAH.