

Occurrence of benzo[a]pyrene in some foods of animal origin in the Slovak Republic

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SUMMARY

A total of 10 841 food products of animal origin such as smoked meat products, canned meat products, poultry products, fish and fish products and animal fats to be sold on the Slovakian market were analysed for the presence of benzo[a]pyrene (BaP) in accredited state control laboratories in the frame of official controls and monitoring of food quality during 1994–2005. Results were summarized and compared with maximum acceptable levels set by European Commission Regulation (EC) No 1881/2006. As found, BaP contents were above the limit in 1.6% of all foods. The maximum acceptable BaP contents of $5 \mu\text{g.kg}^{-1}$ were above the limit mainly in smoked meat products, where also extremely high BaP content at the level of $700 \mu\text{g.kg}^{-1}$ was found in sausage smoked at uncontrolled domestic conditions. Total average BaP contents in controlled food commodities were as follows: fish and fish products - $1.15 \mu\text{g.kg}^{-1}$, smoked meat products - $1.02 \mu\text{g.kg}^{-1}$, animal fats - $0.35 \mu\text{g.kg}^{-1}$, poultry products - $0.30 \mu\text{g.kg}^{-1}$ and canned meat products - $0.25 \mu\text{g.kg}^{-1}$.

KEYWORDS

polycyclic aromatic hydrocarbons; benzo[a]pyrene; maximum level; smoked meat; fish; animal fat; poultry

Polycyclic aromatic hydrocarbons (PAHs) are generally classified as relatively persistent organic environmental contaminants. Many of them have been identified as carcinogens with possible genotoxic properties. PAHs are a group of over 160 different compounds that are associated mainly with human activities such as industrial and manufacturing processes (power plants, waste incineration, steel and aluminium production, petrochemical and bitumen industries) as well as with home heating, food preparation and smoking. However, PAHs are also formed in the environment during forest fires or volcanic activities, respectively [1]. In general, PAHs are present in various foods such as dairy products, vegetables, fruits, oils, coffee, tea, cereals and smoked meat [2-7]. Special attention is given to food products which are flavoured with smoke, grilled or dried using hot combustion products because the highest levels of PAHs were found therein [1, 8-10].

At present, attention is mainly paid to compounds able to cause serious illness in living organisms, such as benzo[a]anthracene, benzo[k]fluoranthene, dibenzo[a,h]anthracene, diben-

zo[a,l]pyrene, benzo[a]pyrene, benzo[g,h,i]perylene, dibenzo[a,e]pyrene, indeno[1,2,3-c,d]pyrene, benzo[b]fluoranthene, chrysene, dibenzo[a,h]pyrene, 5-methylchrysene, benzo[j]fluoranthene, cyclopenta[c,d]pyrene, dibenzo[a,i]pyrene and benzo[c]fluorene. To simplify assessment of toxicological risk measures coming from different effects of these compounds, benzo[a]pyrene (BaP) has been accepted as the indicator of PAH presence in food due to its most intense carcinogenicity. European Commission Regulation No 466/2001 as amended by the regulation 208/2005 sets maximum levels for BaP in some foods to be sold on the European market. In 2006, Commission Regulation No 466/2001 was replaced by European Commission Regulation No 1881/2006 and started to be applied from March 1, 2007. Maximum levels in muscle meat of smoked fish, smoked fishery products, smoked meat and smoked meat products are $5 \mu\text{g.kg}^{-1}$ or $2 \mu\text{g.kg}^{-1}$ for vegetable and animal oils and fats, muscle meat of fish, other than smoked fish intended to be used for direct human consumption, or use as an ingredient in food [11]. The objective of this article was to summarise

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the BaP occurrence in some foods of animal origin to be sold in the Slovak Republic which was monitored during 1994–2005.

MATERIALS AND METHODS

From 10 841 samples, smoked meat products (8438 samples), canned meat products (108 samples), poultry products (481 samples), fish and fish products (1061 samples) and animal fat (753 samples) were analysed in the frame of official controls of food quality and the Market Basket Monitoring (MBM) project. MBM is a part of the Partial Monitoring System of Contaminants in Food and Feed being active in the Slovak Republic to analyse systematically an occurrence of contaminants as well as a level of contamination in food chain.

The monitoring (development of methodology, sampling plan, analyses and drafting of annual reports) was coordinated by the State Veterinary and Food Authority of the Slovak Republic. Regional Veterinary and Food Administrations participated in the sampling procedures and accredited institutions of the State Veterinary and Food Authority (located in Bratislava, Dolný Kubín and Košice) performed the analyses. All laboratories took part in interlaboratory comparative tests and applied validated chromatographic analytical methods. Obtained results were summed up and evaluated at the Department of Risk Assessment and Food Composition Databases of Food Research Institute in Bratislava according to Commission Regulation No 1881/2006 [11].

RESULTS AND DISCUSSION

On the basis of obtained results it was found that 169 (1.6%) samples exceeded the maximum

acceptable levels set by Regulation No 1881/2006 (Tab. 1). In the past, the Slovak Republic had applied a stricter limit value on the contents of BaP within the national legislation till the new EC regulation 1881/2006 came to force [11]. Instead of the former national limits ($1 \mu\text{g.kg}^{-1}$ BaP for smoked meat products and non-smoked fish products, $2 \mu\text{g.kg}^{-1}$ BaP for smoked fish products), the less strict limits laid down by the EU regulation are applied at present ($5 \mu\text{g.kg}^{-1}$ BaP for smoked meat products and smoked fish products, $2 \mu\text{g.kg}^{-1}$ BaP for non-smoked fish products). If the former national limits were in force, the number of non-complying samples would be by far higher - 1147 (10.6%).

Poultry products

During the period of monitoring, out of the total number of 481 samples of poultry products analysed, current limit levels [11] were not exceeded. From 1994 to 2005, the average one-year BaP content in poultry products ranged between $0.18 \mu\text{g.kg}^{-1}$ (1998) and $0.57 \mu\text{g.kg}^{-1}$ (1996), and the total average BaP content was $0.30 \mu\text{g.kg}^{-1}$ for the entire period of monitoring (Fig. 1). If the previous legislation was in force, the percentage of non-complying samples would be increased to 13.3% (64 samples).

Canned meat

In 108 analysed canned meat samples, BaP content above the maximum level [11] was not found. From 1994 to 2005, the average content of BaP in canned meat ranged between $0.04 \mu\text{g.kg}^{-1}$ (1994) and $0.47 \mu\text{g.kg}^{-1}$ (1999), the average content of BaP was $0.25 \mu\text{g.kg}^{-1}$ for the entire period of monitoring (Fig. 1). However, if the previous national limit was taken into consideration, the number of non-complying samples would reach 11.1 % (12 samples).

Tab. 1. Number of samples some foods of animal origin to be found during 1994–2005 in the Slovak Republic.

Commodity	Number of samples	Number of samples exceeding the limit	Percentage of samples exceeding the limit [%]	Total average BaP content [$\mu\text{g.kg}^{-1}$]	Median	95th percentile	Standard deviation
Smoked meat products	8 438	33	0.39	1.02	0.20	1.00	19.55
Canned meat products	108	0	0	0.25	0.10	1.00	0.37
Poultry products	481	0	0	0.30	0.27	1.00	0.30
Fish products	1 061	128	12.06	1.15	0.27	5.10	3.54
Animal fats	753	8	1.06	0.35	0.27	1.00	0.62
Total	10 841	169	1.56	–	–	–	–

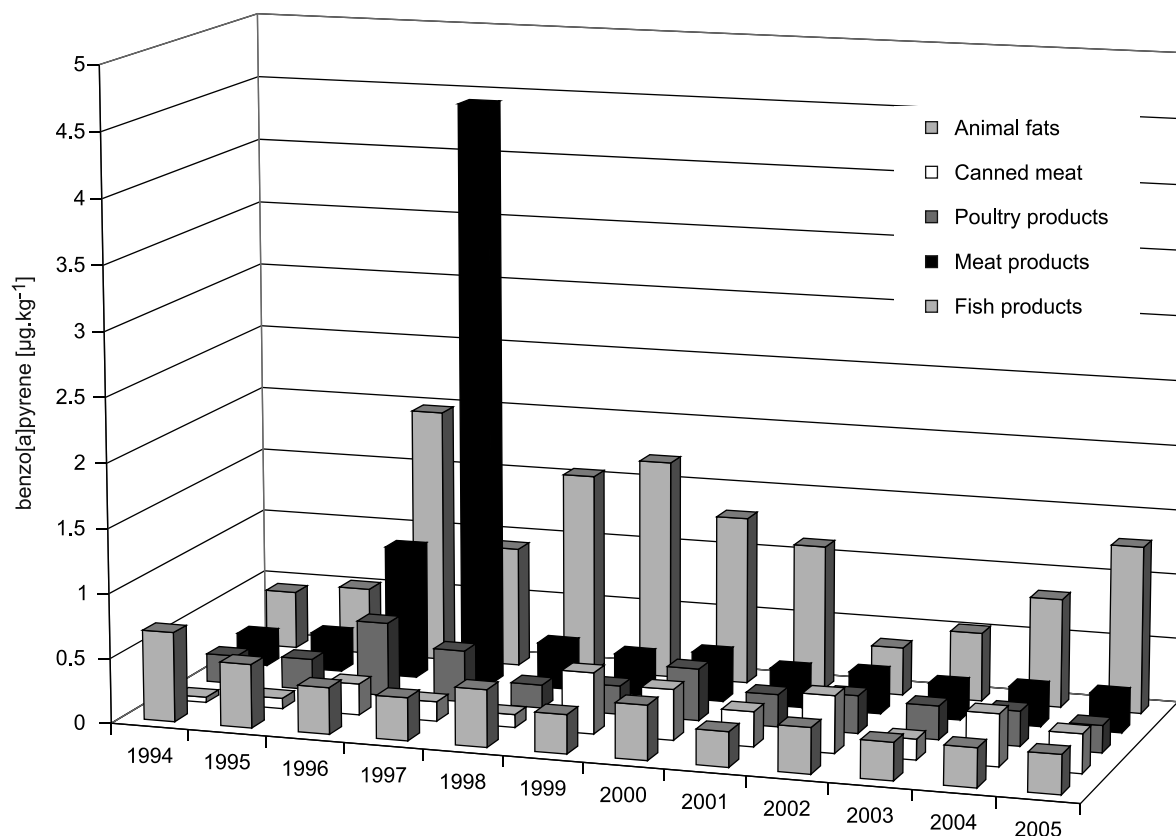


Fig. 1. One-year average BaP content [$\mu\text{g.kg}^{-1}$] in food categories during 1994–2005.

Smoked meat products

Out of the total of 8438 samples of smoked meat products taken, 33 samples (0.4%) exceeded the permissible limit set for BaP. The average values of BaP in the meat products highly exceeded the maximum permissible limit in 1997 and 1996. In 1997, contents of BaP was above the limit in 10 samples, and contents as high as $700 \mu\text{g.kg}^{-1}$ were determined in home-made smoked sausage (8 samples). In 1996, 17 samples exceeded the maximum level and these were smoked pork (rib, hip) produced in Slovakia. From 1994 to 2005, the yearly average content of BaP in meat products ranged between $0.24 \mu\text{g.kg}^{-1}$ (1994) and $4.52 \mu\text{g.kg}^{-1}$ (1997) and the average content of BaP was $1.02 \mu\text{g.kg}^{-1}$ for the entire period of monitoring (Fig. 1). In the last 5 years, the number of samples with BaP contents exceeding the limit was very low (not more than 2 non-complying samples per year). “Wild” smoking under uncontrolled technological conditions and the non-existing legislative measures, what is typical in particular for households and developing countries, leads to enormous PAHs contents in smoked foods [12, 8]. Very high

BaP levels may be found in intensively smoked products - black-smoked or farmhouse-smoked products [13]. This is illustrated by our findings in home-made smoked sausage, in which BaP level reached $700 \mu\text{g.kg}^{-1}$, what exceeded the limit set by current EU legislation by 140 times. If we would apply the requirements of the former national legislation, the number of samples exceeding this limit would increase from 0.4% to 12.7% (from 33 samples to 1071 samples).

Fish and fish products

During the period of monitoring, out of the total number of 1 061 samples of fish and fish products, 128 samples (12.1%) exceeded the applicable limit. If the results were evaluated according to the former national legislation, the number of non-complying samples would increase to 302 (28.5%). A major part of the samples exceeding the limit comprised imported sprats in oil, smoked sprats, canned sea fish in oil, smoked herrings and smoked mackerels from Latvia, Estonia, Poland and Lithuania. The highest BaP value of $59.9 \mu\text{g.kg}^{-1}$ was determined in the sample of sprats

in oil imported from Poland in 1998. The highest number of samples exceeding the limit was in 1996–1999 (26 samples per year on average), but during 2001–2005, the number of non-complying samples significantly decreased to 3 samples per year on average. From 1994 to 2005, the average content of BaP in fish products ranged between $0.37 \mu\text{g.kg}^{-1}$ (2002) and $1.98 \mu\text{g.kg}^{-1}$ (1996), the average content of BaP was $1.15 \mu\text{g.kg}^{-1}$ for the entire period of monitoring (Fig. 1).

Although the bioaccumulation potential of PAHs is very low, these compounds are taken-up rapidly and readily by marine organisms, such as fish, in which they become transformed into carcinogenic compounds and at high doses can induce tumor formation [14, 15]. On the other hand, the amount of PAH formed during processing of fish depends mostly on the conditions of smoking. In traditional smoking, smoke is generated at the bottom of an oven and the food is placed directly over the smoking wood. In modern industrial smoking ovens, smoke is generated in a separate chamber and led into the smoking chamber where the products are placed. This facilitates a better control of the smoking process [13]. By far more dangerous is the smoking process at uncontrolled conditions, typical for home “wild” smoking for the preparation of heavy-smoked products as well as smoking carried out in developing countries without any application of good manufacturing practice principles and official hygienic control measures [12, 16].

Animal fat

Out of the total number of 753 samples of animal fat, 8 samples (1.1%) exceeded the limit. The values above the limit ranged between $2.1 \mu\text{g.kg}^{-1}$ and $8.5 \mu\text{g.kg}^{-1}$ and were determined for samples of smoked bacon produced in Slovakia. From

1994 to 2005, the average content of BaP in animal fat ranged between $0.27 \mu\text{g.kg}^{-1}$ (2001) and $0.69 \mu\text{g.kg}^{-1}$ (1994), the average content of BaP was $0.35 \mu\text{g.kg}^{-1}$ for the entire period of monitoring (Fig. 1). The highest overall average content of BaP is shown in Fig. 2. The highest levels were detected in fish products ($1.15 \mu\text{g.kg}^{-1}$) and meat products ($1.02 \mu\text{g.kg}^{-1}$). Occurrence of PAHs in these commodities is ascribed to processes of drying, frying and smoking.

CONCLUSIONS

BaP content in some foods of animal origin was monitored in the Slovak Republic during 1994–2005. In this period, the one-year average BaP contents in selected commodities ranged between $0.25 \mu\text{g.kg}^{-1}$ and $1.05 \mu\text{g.kg}^{-1}$ as follows: $1.02 \mu\text{g.kg}^{-1}$ in smoked meat products, $0.25 \mu\text{g.kg}^{-1}$ in canned meat products, $0.30 \mu\text{g.kg}^{-1}$ in poultry products, $1.15 \mu\text{g.kg}^{-1}$ in fish products and $0.35 \mu\text{g.kg}^{-1}$ in animal fats. Out of the total of 10 841 samples taken, 169 (1.6%) samples exceeded the limit for BaP contents set by the current European legislation. The highest BaP levels were detected in smoked meats products and the lowest ones were determined for the samples of canned meat products and poultry products. The most contaminated sample was a home-made smoked sausage contaminated at a level of $700 \mu\text{g.kg}^{-1}$, which exceeded the limit by 140 times. It confirms a fact that PAH presence in smoked products is really a considerable risk factor for consumers, in particular in case of the production at uncontrolled conditions. In order to minimize these risks and eliminate PAH impact on public health, continuous monitoring of their presence is necessary also in the next future.

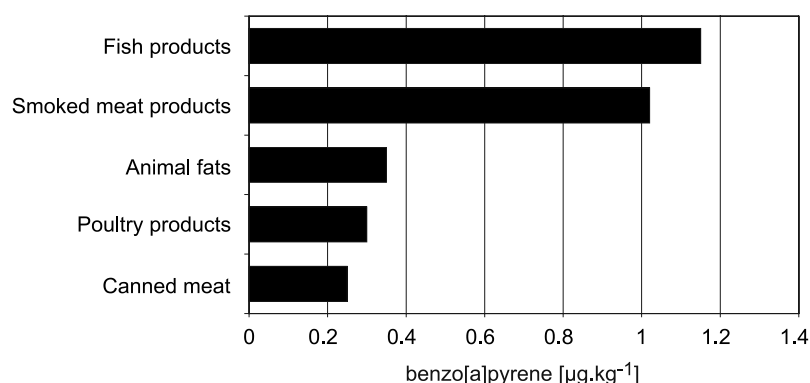


Fig. 2. Food categories arranged by total average BaP content [$\mu\text{g.kg}^{-1}$] to be found during 1994–2005.

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