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Polycyclic aromatic hydrocarbons (PAHs) in different types of smoked meat products from Serbia

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Abstract

The contents of the16 EU priority PAHs in six different meat products from Serbia (beef ham, pork ham, bacon without skin, bacon with skin, cajna sausage and sremska sausage) were examined during the process of smoking. All these meat products from meat industry Zlatiborac, Mačkat, Serbia presented in this study, have not previously been analysed concerning to their contents of PAH compounds. Determination and quantification of PAHs in meat products were performed by a Fast GC/HRMS method. The maximum level for benzo[*a*]pyrene (B*a*P) of 5 μg/kg in smoked meat products was not exceeded in any samples. B*a*P comprises in general 4.6% of the total sum of the 16 EU priority PAHs and 15.2% of the total sum of the 12 IARC PAH compounds. The suitability of B*a*P as a marker both for 16 EU priority PAHs and 12 IARC probably and possibly carcinogenic PAHs was checked by applying correlation analysis.

Keywords: Polycyclic aromatic hydrocarbons; Smoked meat products; B*a*P as a marker; Correlation statistic analysis

1. Introduction

Polycyclic aromatic hydrocarbons (PAHs) represent a group of organic compounds consisting of two or more condensed aromatic rings that are widely geographically distributed and remain in the environment for a long time (Howsam, Jones, & Ineson, 2000). A number of them, such as benzo[*a*]pyrene, are carcinogenic and mutagenic (Du Four, Janssen, Brits, & Van Larebeke, 2005), and they are widely believed to make a substantial contribution to the overall burden of cancer in humans (Phillips, 1999). Due to these properties they are considered to be top of the list of the most hazardous substances. Harmful effects of PAHs on living organisms have been observed for years.

PAHs can be found throughout the environment in water (Barth et al., 2007; Fernandes, Sicre, Broyelle, Lorre, & Pont, 1999), atmosphere (Chung-Yih, Hong-Shen, & Jeang-Hung, 2006) and sediment (Lauenstein & Kimbrough, 2007). Foods may be contaminated through different routes, which include the following: direct deposition of PAHs from the atmosphere as environmental contaminants on various fruits and vegetables (Fismes et al., 2004; Tao et al., 2006; Wennrich, Popp, & Zeibig, 2002); contamination from packaging materials and production of PAHs during the thermal processing of foods, e.g., roasting, charcoal grilling, and smoking (Šimko, 2002, 2005) of food from animals.

Smoking of meat and meat products is one of the most ancient technologies which has been used for thousands of years. Smoking is defined as the process of penetration of meat products by volatiles resulting from thermal destruction of wood (Tóth, 1983). Hundreds of individual PAHs may be formed and released during the incomplete combustion or thermal decomposition (pyrolysis) of the organic material. If the meat is in direct contact with the

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flame, pyrolysis of the fats in the meat generates PAH that become deposited on the meat (Janoszka, Warzecha, Blaszczyk, & Bodzek, 2004).

According to the Scientific Committee on Food (SCF) (European Commission, 2005a) benzo[*a*]pyrene can be used as a marker for the occurrence and impact of carcinogenic PAHs in food.

The Commission recommends the member states of the European Union to analyse the contents of 15 PAH compounds, which are classified as priority (15 SCF–PAH), and to check the suitability of benzo[*a*]pyrene as a marker (European Commission, 2005b). Additionally, the European Food Safety Authority (EFSA) recommends analysis of benzo[*c*]fluorene (B*c*L) assessed to be relevant by the Joint FAO/WHO[1] Experts Committee on Food Additives (JECFA) (2005). PAHs that are recommended to be analysed are: benzo[*c*]fluorene (B*c*L), benzo[*a*]anthracene (B*a*A), cyclopenta[*c*,*d*]pyrene (CPP), chrysene (CHR), 5-methylchrysene (5MC), benzo[*b*]fluoranthene (B*b*F), benzo[*j*]fluoranthene (B*j*F), benzo[*k*]fluoranthene (B*k*F), benzo[*a*]pyrene (B*a*P), benzo[*g*,*h*,*i*]perylene (B*g*P), dibenzo[*a*,*h*]anthracene (D*h*A), indeno[1,2,3-*cd*]pyrene (I*c*P), dibenzo[*a*,*e*]pyrene (D*e*P), dibenzo[*a*,*h*]pyrene (D*h*P), dibenzo[*a*,*i*]pyrene (D*i*P) and dibenzo[*a*,*l*]pyrene (D*l*P) (Fig. 1). D*l*P has been in the spotlight of scientific interest recently because toxicological investigations indicated that dibenzo[*a*,*l*]pyrene probably has a much stronger carcinogenic potential than benzo[*a*]pyrene (Higginbotham, Ramakrishna, Johansson, Rogan, & Cavalieri, 1993). D*l*P is detectable in environmental samples and has been characterized as the most potent carcinogenic species among all PAHs as yet tested in rodent bioassays (Schober et al., 2006).

The Serbian meat industry is interested in studying PAHs in smoked meat and meat products, in order to improve food safety of products from protected geographic areas and their compliance with the EU regulations. Smoked meat products present a significant part of the human diet in Serbia. They are important because of their good taste, high nutritional value, high level of production and large variety of products. The most famous smoked meat products in Serbia originate from the protected geographic area of Zlatibor. That area is on the west of Serbia and about 230 km south-west from the Serbian capital, Belgrade. The tradition of producing smoked meat in Zlatibor has been handed down over centuries. Step by step, the tradition was developed and has become a trademark of the Zlatibor region.

The aim of the present study was on the one hand the investigation of the contents of PAH compounds, which are recommended to be analysed both by the SCF and the EFSA, in six different meat products (beef ham, pork ham, bacon without skin, bacon with skin, cajna sausage and sremska sausage) during process of smoking. On the other hand the suitability of B*a*P as a marker for other carcinogenic PAHs was checked by applying correlation analysis. All these meat products from meat industry Zlatiborac, Mačkat, presented in this study, have not previously been analysed for their contents of PAH compounds.

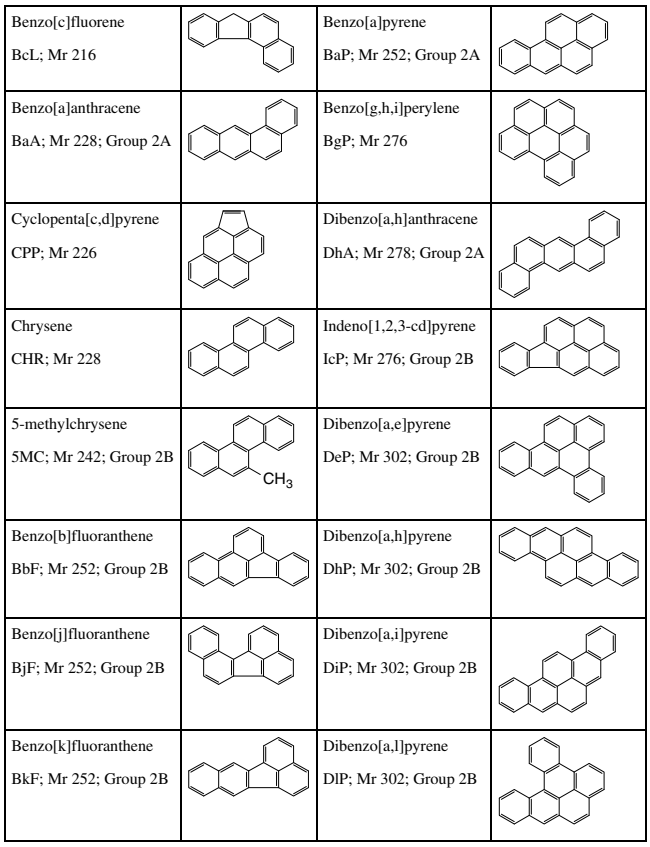

Fig. 1. Chemical structures, abbreviations and relative molecular weights (Mr) of the 16 EU priority PAHs examined in this study and the IARC classification of PAHs (Group 2A: The PAH is probably carcinogenic to humans and Group 2B: The PAH is possibly carcinogenic to humans).

2. Materials and methods

2.1. Food samples and sampling

Six different types of smoked meat products were analysed: beef ham, pork ham, bacon without skin, bacon with skin, cajna sausage and sremska sausage. All samples were collected from meat industry Zlatiborac, Mačkat, Serbia in February 2007. Samples were collected every 3 days during 15 days of smoking (in the case of pork ham, bacon without skin, bacon with skin and sremska sausage) and during 18 days of smoking for beef ham and cajna sausage. All meat products were continuously exposed to smoke which was produced by beech wood combustion. As a control, all products were taken before the process of smoking and marked as samples after 0 days of smoking. Meat products were smoked in two different smokehouses. Ham and bacon samples (Sample A) were placed in the first smokehouse, where a smoke generator was 2 m far from the sam-

[1] Food and Agriculture Organization of the United Nations/World Health Organization.