

PAPER • OPEN ACCESS

## Factors affecting elimination of polycyclic aromatic hydrocarbons from traditional smoked common carp meat

To cite this article: J Babi *et al* 2017 *IOP Conf. Ser.: Earth Environ. Sci.* **85** 012086

View the [article online](#) for updates and enhancements.

### Related content

- [Assessment of polycyclic aromatic hydrocarbons \(PAHs\) ecological risk in surface seawater from the west Bohai Bay, China](#)  
X M Jia, J Y Li and S Y Tian
- [Indoor PM2.5 and its Polycyclic Aromatic Hydrocarbons in Relation with Incense Burning](#)  
Susira Bootdee, Somporn Chantara and Tippawan Prapamontol
- [Characteristics and risks of composite pollutants formed by C1 bituminous coal combustion particulates and polycyclic aromatic hydrocarbons \(PAHs\) in Xuanwei area](#)  
Xurundong Kan, Di Lang, Hao Li *et al.*

### Recent citations

- [Polycyclic aromatic hydrocarbons in traditionally smoked Slavonska kobasica](#)  
Krešimir M. Mastanjevi *et al*

## Factors affecting elimination of polycyclic aromatic hydrocarbons from traditional smoked common carp meat

J Babić<sup>1</sup>, S Vidaković<sup>1</sup>, S Škaljac<sup>2</sup>, B Kartalović<sup>1</sup>, D Ljubojević<sup>1</sup>, M Ćirković<sup>1</sup>, V Teodorović<sup>3</sup>

<sup>1</sup> Scientific Veterinary Institute "Novi Sad", Novi Sad, Serbia

<sup>2</sup> Faculty of Technology, University of Novi Sad, Bulevar Cara Lazara 1, Novi Sad, Serbia

<sup>3</sup> Faculty of Veterinary Medicine, University of Belgrade, Bulevar oslobođenja 18, Belgrade, Serbia

E-mail: jelenababic@niv.ns.ac.rs

**Abstract.** Smoking techniques have been progressively improved and different procedures have been developed in different regions for treating fish. In these times, the technology is mainly used for enrichment of fish with specific taste and odour, to extend the shelf-life of these perishable products and appearance required widely on the market. A lot of chemical contaminants such as polycyclic aromatic hydrocarbons (PAHs) are formed during the combustion of fuel in the smoking process. PAHs are a group of compounds that have been the subject of great concern in the recent years due to their toxic, mutagenic and/or carcinogenic potentials to humans. These fact can have a significant impact on the acceptance of these products by consumers. In this review article, the objective is to describe factors affecting elimination of polycyclic aromatic hydrocarbons from traditional smoked common carp meat.

### 1. Smoked common carp meat

Food smoking is one of the oldest food technologies which mankind has used for at least 10 000 years [1,2]. Production of smoked meat is very popular and smoked meat presents a significant part of the human diet in Serbia and our region, which makes smoked products very popular and consumed quite often and traditional uncontrolled smoke kilns are still widely being used [3].

The fish processing industry is not well developed in our country because for many years the amount of fish was just not enough and also because of the consumers' habits [4]. The consumption of smoked fish in our country is lower compared to other countries in the EU, but it shows the tendency for the significant increase [5]. Within this type of the fish products, the smoked carp, silver carp and trout meat is available in our country and the most famous smoked fish meat is smoked common carp meat [6].

Consumers prefer smoked fish due to several reasons such as taste, amount of essential fatty acids, and readiness to eat [7]. In these times, the technology is mainly used for enrichment of fish with specific taste and odor, to extend the shelf-life of these perishable products and appearance required widely on the market. About 15% of the total quantity of fish for human consumption in Europe is offered on the market in the form of either cold- or hot-smoked products [8]. Traditional smoking involves treating of pre-salted, whole, eviscerated or filleted fish with wood smoke. The most often,



smoke is produced by smouldering wood and shavings or sawdust in the oven, directly below the hanging fish or fillets, laid out on mesh trays.

Fish contains n-3 polyunsaturated fatty acids (PUFAs) that appear to play several useful roles for human health [9]. Conversely, potential health hazards could be associated with smoked foods may be caused by carcinogenic components of wood smoke – mainly polycyclic aromatic hydrocarbons (PAHs), derivatives of PAHs, such as nitro-PAHs or oxygenated PAHs, and to a lesser extent also N-nitroso compounds and heterocyclic aromatic amines [10]. These fact can have a significant impact on the acceptance of these products by consumers.

## **2. Polycyclic aromatic hydrocarbons - PAHs**

A lot of chemical contaminants such as polycyclic aromatic hydrocarbons (PAHs), dioxins, formaldehyde, nitrogen and sulphur oxides are formed during the combustion of fuel in the smoking process [11]. PAHs are a group of compounds that have been the subject of great concern in the recent years due to their toxic, mutagenic and/or carcinogenic potentials to humans. PAHs comprise the largest class of chemical compounds known to be cancer causing agents. Some, while not carcinogenic, may act as synergists. The main route of exposure to PAHs for non-smokers and non-occupationally exposed individuals is through food consumption [12, 13].

PAHs have been detected in food, both raw/non-processed and processed foods. The presence of PAHs in raw foods is associated with environmental pollution [14]. PAHs are found ubiquitously, such as water, air, soil, and, therefore also in food [7]. Due to their lipophilicity, persistence and high toxicity, a lot of studies have shown that in the aquatic habitat, many organisms, such as fish and shellfish, readily accumulate PAHs from the environment and store them in their tissues reaching levels higher than those in the ambient medium [15,16,17,18].

In fact, the International Agency for Research on Cancer classifies some PAHs as known, possibly, or probably carcinogenic to humans (Group 1, 2A or 2B). Among these are benzo[a]pyrene (Group 1), naphthalene, chrysene, benz[a]anthracene, benzo[k]fluoranthene and benzo[b]fluoranthene (Group 2B) [19]. Some PAHs are well known as carcinogens, mutagens, and teratogens and therefore pose a serious threat to the health and the well-being of humans.

## **3. Factors affecting occurrence and concentrations of PAHs in smoked products**

Smoke production in modern smoking ovens is closely controlled and the removal of PAHs and other undesirable compounds is facilitated by the smoke generators being separated from the smoking chamber. In contrast, in traditional smoking conditions, very high combustion temperatures are reached and the foodstuff is in direct contact with all components of the smoke generated. Direct exposition of meat products to smoke brings about higher concentrations of PAHs as compared to indirect methods, when PAHs are partially eliminated by condensation in tars [2,20]. Reports that PAH levels in traditional smoked foods can reach high levels have in recent years prompted considerable interest in their quantification and control.

The composition and amount of PAHs depend upon numerous factors, such as the composition and type of wood as well as moisture content, oxygen accessibility, the temperature of smoke generation, smoking duration etc. [2, 21, 18]. Also, deposition and penetration of smoke components into smoked fish depends on natural content of PAHs in raw fish, water activity of the food, fat content, heat source, distance of heating, design of the food device, drainage of fat etc. [21, 7]. Even, there is evidence showing that female fish exhibited significantly lower mean  $\Sigma$ PAH concentrations than male in all examined the species, except for *Liza abu* [22].

Wood composition, especially lignin content, also influences the levels of PAHs produced [20]. Also, the use of hardwoods instead of softwoods has been recommended to reduce the presence of PAHs in smoke and in smoked foods too [21].

Temperature of smoke generally plays a very important role, because the amount of PAHs in smoke formed during pyrolysis increases linearly with the smoking temperature within the interval

400–1000°C [20]. In addition, PAHs can also be formed at lower temperatures [18]. Also, concentration of PAHs in the smoke increased when the materials were burnt with flames [23, 24].

Simko et al. (1991) have shown the decrease in benzo[a]pyrene content caused by dehydration of product that confirmed the effect of moisture content on PAHs concentration in smoked food [25].

There is a positive relationship between lipid content and PAH residual levels. PAHs are lipophilic in nature and usually accumulate in the fatty tissues of organisms. This provides further evidence that the lipid content of the tissues is the determining factor in the bioaccumulation of PAHs by fish. The formation of PAHs is known to occur through pyrolysis of fat at temperatures above 200 °C and it is highly stimulated at temperatures over 700 °C [7]. Pyrolysis of other organic matter such as proteins and carbohydrates might be involved, but the greatest concentrations of PAHs have been shown to arise from fat pyrolysis. This provides further evidence that the lipid content of the tissues is the determining factor in the bioaccumulation of PAHs by fish [26, 27, 28].

Group of authors Babic et al. have proved that application of charcoal filter [4], zeolite filter [3] and gravel filter [29] in production of smoked common carp meat decrease the PAHs content.

The package of smoked food into appropriate packaging material could also remarkably decrease the PAH content [2]. The highest concentration of PAHs in smoked food usually occur at the food surface and maximum concentration of PAHs is immediately after finishing the smoking, then it decreases due to light decomposition and interaction with present compounds [28].

#### 4. Conclusions

Studies focused on the effects of smoking on the potential changes, increases or decreases, of chemical contaminants such as PAHs in smoked common carp meat are very important because this may be a contributing factor to the recent increases in prevalence rates in cases of cancer in our country.

There is therefore a need to educate manufacturers about safe smoking practices, and also most importantly to adopt their procedure that would reduce PAHs content in smoked common carp meat with traditional kilns in order to ensure the health safety of consumers. Levels of contamination can be significantly reduced under controlled conditions accepting good manufacturing practice principles using current knowledge and appropriate technological equipment.

#### References

- [1] Simko P 2002. Determination of polycyclic aromatic hydrocarbons in smoked meat products and smoke flavouring food additives. *J Chromatogr B Analyt Technol Biomed Life Sci.* **770** 3-18
- [2] Simko P 2005. Factors affecting elimination of polycyclic aromatic hydrocarbons from smoked meat foods and liquid smoke flavorings. *Mol. Nutr. Food Res.* **49** 637-647
- [3] Babić J, Kartalović B, Petrović J, Okanović Đ, Novakov N, Ljubojević D, Ćirković M, Teodorović V 2017. The application of zeolit filter in production of smoked common carp meat. *Proceedings of V International congress „ Engineering, enviroment and materials in processing industry“*, Jahorina 15th-17th March 2017, Republic of Srpska, Bosnia and Herzegovina, 189-196
- [4] Babić J, Kartalović B, Petrović J, Okanović Đ, Novakov N, Ljubojević D, Ćirković M, Teodorović V 2017. The application of charcoal filter in production of smoked common carp meat. *Proceedings of V International congress „ Engineering, enviroment and materials in processing industry“*, Jahorina 15th-17th March 2017, Republic of Srpska, Bosnia and Herzegovina, 181-189
- [5] Ćirković M, Ljubojević D, Okanović Đ, Đorđević V, Novakov N 2014. Effect of hot smoking process on processing yield and microbiological safety of Common Carp, *II International Congress “Food Technology, Quality and Safety” (FoodTech2014)*, *Proceedengs*, 100-104
- [6] Pavličević N, Đorđević V, Dimitrijević M, Karabasil N, Baltić M, Bošković M, Petrović J 2013. Effect of pre-processing of trout by freezing on the characteristics of smoked trout fillets, *Tehnologija mesa* **54** 57–68

- [7] Bansal V, Kim K-H 2015. Review of PAH contamination in food products and their health hazards. *Environ Int.* **84** 26–38
- [8] Stolywo A, Sikorski Z 2004. Polycyclic aromatic hydrocarbons in smoked fish – a critical review, *Food Chemistry* **91** 303-311
- [9] Liu J, Ma D W L 2014. The Role of n-3 Polyunsaturated Fatty Acids in the Prevention and Treatment of Breast Cancer. *Nutrients* **6** 5184–5223
- [10] Shen G, Tao S, Wei S, Zhang Y, Wang R, Wang B, Li W, Shen H, Huang Y, Chen Y, Chen H, Yang Y, Wang W, Wang X, Liu W, Simonich SLM 2012. Emissions of Parent, Nitro, and Oxygenated Polycyclic Aromatic Hydrocarbons from Residential Wood Combustion in Rural China. *Environ. Sci. Technol.* **46** 8123–8130
- [11] CAC/RCP 68-2009 Code of practice for the reduction of contamination of food with polycyclic aromatic hydrocarbons (pah) from smoking and direct drying processes. World Health Organization & Food and Agriculture Organization of the United Nations
- [12] Ma Y, Harrad S 2015. Spatiotemporal analysis and human exposure assessment on polycyclic aromatic hydrocarbons in indoor air, settled house dust, and diet: A review. *Environ Int.* **84** 7-16
- [13] Domingo J, Nadal M 2015. Human dietary exposure to polycyclic aromatic hydrocarbons: A review of the scientific literature. *Food and Chemical Toxicology* **86** 144-153
- [14] Guillen MD, Sopelana, P, Partearroyo MA 2000. PAH in liquid smoke flavorings obtained from different types of wood. Effect of storage in polyethylene flasks on their concentrations. *Journal of Agricultural and Food Chemistry* **48** 5083–5087
- [15] Shadi A, Mazandarani MK, Nikpour Y 2012. Concentrations of polycyclic aromatic hydrocarbons (PAHS) in sediments of Khowre-Musa System (Persian Gulf). *World* **4** 83–86
- [16] Johnson LL, Arkoosh MR, Bravo CF, Collier TK, Krahn MM, Meador JP, Myers MS, Reichert WL, Stein JE 2008. The Effects of Polycyclic Aromatic Hydrocarbons in Fish from Puget Sound, Washington, ed Di Giulio RG and Hinton DE (Taylor & Francis Group, LLC) 873-919
- [17] Dhananjayan V, Muralidharan S 2012. Polycyclic Aromatic Hydrocarbons in Various Species of Fishes from Mumbai Harbour, India, and Their Dietary Intake Concentration to Human. *International Journal of Oceanography* 2012, 6 pages
- [18] Abdel-Shafy H I, Mansour M S M 2016. A review on polycyclic aromatic hydrocarbons: Source, environmental impact, effect on human health and remediation. *Egyptian Journal of Petroleum* **25** 107-123
- [19] IARC (International Agency for Research on Cancer) 2010. Some non-heterocyclic polycyclic aromatic hydrocarbons and some related exposures *Monogr Eval Carcinog Risks Hum* **92** 765-771
- [20] Nollet LML 2007. Handbook of Meat, Poultry and Seafood Quality. Blackwell Publishing
- [21] García-Falcón M S, Simal-Gándara J 2005. Polycyclic aromatic hydrocarbons in smoke from different woods and their transfer during traditional smoking into chorizo sausages with collagen and tripe casings. *Food Additives & Contaminants* **22** 1-8
- [22] Rahmanpour S, Ghorghani NF, Masoumeh S, Ashtiyani L 2014. Polycyclic aromatic hydrocarbon (PAH) in four fish species from different trophic levels in the Persian Gulf. *Environmental Monitoring and Assessment* **186** 7047–7053
- [23] Lijinsky W 1991. The formation and occurrence of PAH associated with food. *Mutation Research* **259** 251–261
- [24] Rey Salgueiro L, García Falcón MS, Soto Gonza´lez B, Simal Gandara J 2004. Procedure to measure the level of PAH in wood ashes used as fertilizer in agroforestry soils and their transfer from ashes to water. *Journal of Agricultural and Food Chemistry* **52** 3900–3904
- [25] Simko P, Karovicová J, Kubincová M 1991. Changes in benzo[a]pyrene content in fermented salami. *Z. Lebensm. Unters. Forsch.* **193** 538-540
- [26] Basak S, Sengor G F, Karakoc F T 2010. The Detection of Potential Carcinogenic PAH Using

- HPLC Procedure in Two Different Smoked Fish, Case Study: Istanbul/Turkey. *Turkish Journal of Fisheries and Aquatic Science* **10** 351-355
- [27] Xu FL, Wu WJ, Wang JJ, Qin N, Wang Y, He QS, He W, Tao S 2011. Residual levels and health risk of polycyclic aromatic hydrocarbons in freshwater fishes from Lake Small Bai-Yang-Dian, Northern China. *Ecol Model* **222** 275–286
- [28] Essumang DK, Dodoo DK, Adjei JK 2014. Effective reduction of PAH contamination in smoke cured fish products using charcoal filters in a modified traditional kiln, *Food Control* **35** 85-93
- [29] Babić J, Kartalović B, Petrović J, Okanović Đ, Božić B, Pelić M, Ćirković M 2015. Ecological safe production of smoked common carp meat. „*One Health – New Challenges*“, Novi Sad, Serbia. *First International Symposium of Veterinary Medicine (ISVM2015), Proceedings* 142 – 147