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

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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 Σ 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.

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