Polycyclic aromatic hydrocarbons formation in different types of charcoal grilled meat

Olga Viegas [1,2], Iria Yebra-Pimentel [2], Gastón I. Pancrazio [1,2], Mafalda Prucha [2], Isabel M. P. L. V. O. Ferreira[2] and Olivia Pinho[1,2]

[1]Faculdade de Ciências da Nutrição e Alimentação, Universidade do Porto, Porto, Portugal

[2]REQUIMTE, Laboratório de Bromatologia e Hidrologia, Departamento de Ciências Químicas, Faculdade de Farmácia, Universidade do Porto, Porto, Portugal

Introduction

Charcoal grilling meat involves high temperatures that lead to production of cooking chemical hazards, such as polycyclic aromatic hydrocarbons (PAHs). PAHs are formed from a variety of combustion and pyrolysis processes and thus their sources are numerous, however food seems to be the major route of exposition. The highest PAHs concentration is usually found in charcoal grilled foods and contributes significantly to the intake of PAHs if such foods are a large part of the usual diet.

PAHs are the largest class of known chemical carcinogens, however according to the EU Scientific Committee on Food, the most suitable indicator for the occurrence and carcinogenic potency of PAHs in food is the sum of the following eight PAHs (PAH8): BaP, Ch, BaA, BbF, BkF, BgP, DhA, and IP [1].

The presence of PAHs in charcoal grilled meat is a matter of concern to consumers, because even if present in low levels, the intake of this type of food can be quite frequent and represent a portion higher than 100 g per meal. However, PAHs extraction and quantification in grilled meat is difficult because they occur in food at ppb or lower levels and many organic components can be co-extracted from the matrix. The analytical strategy selected for the present study consisted in extraction using sonication followed by purification on SPE, and analyses by high performance liquid chromatography with fluorescence detection [2]. This strategy allows better extraction efficiency and detection limits lower than those referred by new European Legislation[3].

The goal of this work was the quantification of carcinogenic polycyclic aromatic hydrocarbons(PAH8) in charcoal grilled beef, pork and chicken using domestic grilling conditions. In addition it was estimated the intake per 100g of cooked meat.

Methods

Samples preparation

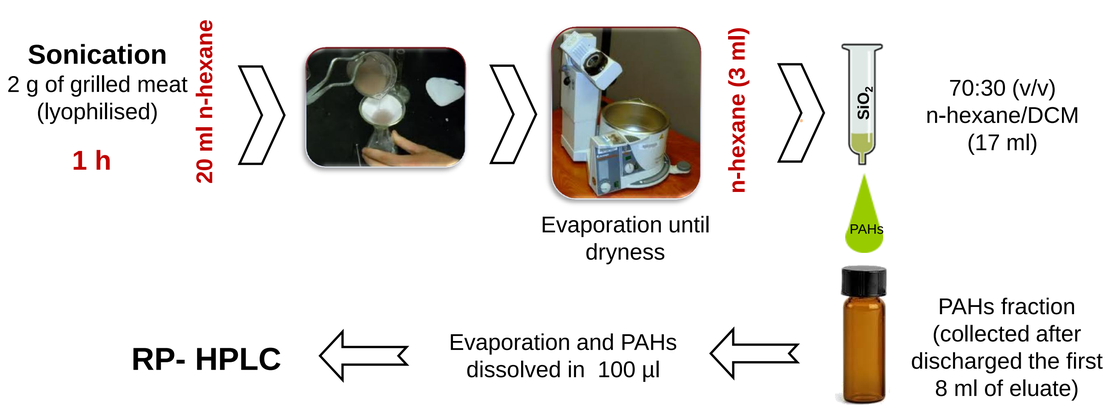
Table 1 Dimensions and grilling conditions of each sample

Sample	Sample dimensions		Grilling conditions*	
	Thickness (cm)	Weight (g)	Time (min)	Temperature (C)
Beef	2.5	350	18	200
Loin of pork	0.5	100	10	200
Chicken	Whole, open in breast		30	200

***** All samples were grilled on charcoal using an appropriate device. The internal temperature reached the minimum 75 ºC and the visual aspect of the final products was well-done.

PAHs analysis (based on Viegas et al [2])

Extraction



HPLC-FLD conditions

- Column – C_{18} RP: Supelcosil™ LC-PAH (Supelco) (5 µm; 25 cm; 4.6 mm)
- Eluents - solvent A, MeOH/H2O (75:25); solvent B, 100% MeOH; solvent C, 100 % Ethyl Acetate
- Flow-rate - 1.0 mL/min at 32 ± 0,2 ºC
- **Table 2** Program of gradient elution

Time (minutes)	Solvent A (%)	Solvent B (%)	Solvent C (%)
0	100	0	0
18	20	80	0
19	0	100	0
20	0	90	10
28.5	0	82	18
37.5	0	80	20
40	0	100	0
45	100	0	5

- Excitation/ emission wavelengths: 270/390 nm for BaA and Ch; 260/430 nm for BbF; 290/410 for BkF, BaP, DhA and BgP; 293/498 for IP.
- Quantification of PAHs in meat samples was performed by standard addition method

Results and Discussion

PAHs formation in charcoal grilled meat

The formation of PAH8 in grilled samples is presented in Table 3. BaA, Ch, BbF, BkF, BaP, IP, BgP, DhA were quantified at least in one type of meat. Quantitative PAHs profiles were different for beef pork, and chicken. Higher levels of PAHs were found in pork, and chicken samples.

Table 3 PAHs content on beef, pork and chicken charcoal grilled

	Beef	Pork	Chicken
	Mean ± SD (ng/g)	Mean ± SD (ng/g)	Mean ± SD (ng/g)
PAH8			
BaA	0.39 ± 0.17^{a}	3.93 ± 0.73^{b}	3.50 ± 0.90^{b}
Ch	0.50 ± 0.10^{a}	7.45 ± 0.66^{b}	5.26 ± 0.71^{c}
BbF	1.03 ± 0.25^{a}	3.23 ± 0.96^{b}	6.28 ± 1.87^{c}
BkF	0.25 ± 0.20^{a}	0.39 ± 0.39^{a,b}	0.84 ± 0.15^{b}
BaP	0.41 ± 0.09^{a}	2.71 ± 0.87^{b}	3.14 ± 0.40^{b}
DhA	traces^{a}	0.24 ± 0.38^{a}	traces^{a}
BgP	0.64 ± 0.18^{a}	1.36 ± 0.52^{b}	2.65 ± 0.33^{c}
IP	traces^{a}	1.26 ± 0.41^{b}	3.30 ± 0.14^{c}

a-c Different letters within the same column differed significantly ($p<0.05$).

EFSA [1] presented mean barbecued meat concentrations of BaP and PAH8 as 1.92 and 7.96 ng/g, respectively. In beef samples these values were lower (0.41 and 3.20ng/g, respectively), however, pork and chicken samples exhibited higher levels of BaP (respectively, 2.71 and 3.14ng/g) and PAH8 (respectively, 20.58 and 24.97ng/g) than the average reported.

Chicken and pork exhibited the highest amount of PAHs and much lower amount was quantified in beef. BaP and PAH8 contents were significantly correlated ($p < 0.05$) with each other and with the fat content of the raw meat (fat data was taken from INSA [4]). Fat drips from samples in charcoal leading to flame formation that increases the smoke release that carries PAHs.

Intake of PAHs from charcoal grilled meat

Intake of PAH8 from beef, pork and chicken meat was calculated on the basis of average consumption of 100 g of grilled meat (Figure 1).

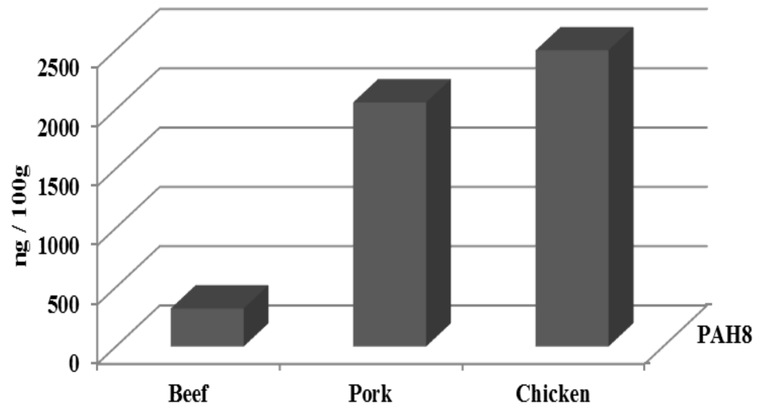


Figure 1. Intake of PAH8 expressed as ng per 100 g of cooked meat

EFSA[1] reported exposure of 279 ng/day of PAH8 from meat and meat products on basis in the average consumption across Europe (132 g/day) and the occurrence data on PAHs concentrations in this food group. Considering these consumption, the intake per day of PAH8, from grilled meat exceeds 279 ng/g. Concerning pork and chicken samples the intake was extremely high. If grilled chicken or pork are consumed in one meal, theoretically the PAH8 intake will exceed even the dietary exposure of high consumers across Europe (range: 1415–2136 ng/day) estimated by EFSA[1].

Conclusions

BaP and PAH8 contents were significantly correlated ($p < 0.05$) with each other indicating that BaP is a good marker of the occurrence and carcinogenic potency of PAHs. The consumption of charcoal grilled fatty meat leads to an exposure to PAHs that considerably exceeds the estimated average intake of PAH8 across Europe and even the dietary exposure of high consumers estimated by EFSA[1].

Acknowledgements: Authors acknowledge financial support from Projects IJUP PP-IJUP2011-332 from University of Porto.

References: [1] EFSA, 2008. Scientific opinion of the panel on contaminants in the food chain on a request from the European Commission on polycyclic aromatic hydrocarbons in Food. EFSA J. 724, 1–114. **[2]** Viegas, O.; Novo, P.; Pinho, O.; Ferreira, I.M.P.L.V.O. A comparison of the extraction procedures and quantification methods for the chromatographic determination of polycyclic aromatic hydrocarbons in charcoal grilled meat and fish. Talanta. 2012, 88, 677-683. **[3]** Commission Regulation (EC), No 836/2011 of 19 August 2011, Off. J. Eur. Union L215, 9–16. **[4]** INSA-Instituto Nacional de Saúde Dr. Ricardo Jorge, 2006. Portuguese Food Composition Table, ed. Centro de Segurança Alimentar e Nutrição INSA, Lisboa.