POLYCYCLIC AROMATIC HYDROCARBONS FORMATION IN DIFFERENT TYPES OF CHARCOAL GRILLED MEAT

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Abstract –The goal of this work was the quantification of carcinogenic polycyclic aromatic hydrocarbons(PAHs) in charcoal grilled beef, pork and chicken using domestic grilling conditions and estimation of intake per 100g of cooked meat.All samples were grilled at 200 ºC. The visual aspect of the final products was well-done.PAHsextraction was performed using sonication followed by purification on SPE, and analyses by high performance liquid chromatography and fluorescence detection.Different quantitative profileswere observed in meat samples for the eight PAHsselected as indicators of carcinogenic PAHs in foods (PAH8). Benzo[a]pyrene(BaP) usually described as PAHs marker was 0.41, 2.71 and 3.14 ng/g, respectively, in beef, pork and chicken). Concerning PAH8 the mean levels were 3.20, 20.58 and 24.97 ng/g in the same samples.BaP and PAH8 were significantly correlated ($p < 0.05$) with fat content of raw meat. Positive correlation between BaP and PAH8 indicates that BaP is a good marker of the occurrence of PAHs. The consumption of charcoal grilled fatty meat leads to an extremelyhigh dietary exposure to PAHs.

Key Words – Charcoal grilled beef, Cooking chemical hazards, Pork and chicken, PAH8

I. INTRODUCTION

Charcoal grilling meat involves high temperatures that lead to production of cooking chemical hazards, such aspolycyclic aromatic hydrocarbons (PAHs).PAHs are formed from a variety of combustion and pyrolysisprocesses and thus their natural or anthropogenic sources arenumerous, however food is also an important exposition source.The highest PAHs concentration are 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 [1]. The EU selected the sum ofeightPAHs (benzo[a]anthracene (BaA), chrysene (Ch), benzo[b]fluoranthene(BbF), benzo[k]fluoranthene (BkF), benzo[a]pyrene (BaP),dibenzo[a,h]anthracene(DhA), benzo[g,h,i]perylene (BgP),indeno[1,2,3-cd]pyrene (IP)) as the most suitable indicators ofcarcinogenic PAHs in food, this PAH8 are the eight high molecularweight/carcinogenic from US-EPA list [2].

The presence of PAHs in charcoal grilled meatis a matter of concern to consumers, because even if present inlow levels, the intake of this type of food can be quite frequent andrepresent 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 andmany organic components can be co-extracted fromthe matrix.Thus, inconstantrecoveries and in some cases interfering peaks in the chromatograms are frequent in the methods described in literature [3].The analytical strategy selectedin the present study consisted in extraction using sonicationfollowed by purification on SPE,and analyses by high performance liquidchromatography with fluorescence detection. This strategy allows better extraction efficiencyanddetection limitslowerthan those referred by new European Legislation[3].

The goal of this work was the quantification of PAH8 in charcoal grilled beef, pork and chicken using home domestic grilling conditions and estimation of intake per 100g of cooked meat.

II. MATERIALS AND METHODS

Sample preparation

For preparation of charcoal barbecued meat, a bed ofcharcoal was prepared and ignited using an appropriate deviceof 35 cm width, 52 cm length, and 15 cm height. When all flameshad subsided, the bed was leveled by raking. Meat samples were preparedresembling usual consumer preferences.

Thus, thesample dimensions and cooking time varied, 2.5 cm of thickand 350 gweigh for lean beef that was cooked 18 min; 0.5 cm of thickand 100 gweigh for loin ofpork skin onthat was cooked 10 min; and chickens open in thebreast and cooked during 30 min.All samples weregrilled at 200 ºC. The internal temperaturereached the minimum 75 ºC and the visual aspect of the final products was well-done.

After cooking the samples werefreeze-dried with a freeze dryer (Cryodos-90, from Telstar®,Terrassa, Spain) and reduced to a fine powder with a knife mill(Grindomix GM 200, Retsch, Hann, Germany).

PAHs Analysis

Extraction and clean up procedures were performed according by Viegas*et al.*[3] for grilled muscle foods. PAHs separation was carried out using a HPLC unit equipped with one HPLCpump PU-1580, a fluorescence detector Jasco FP-920 and an auto sampler AS-950equipped with a 20 µL loop (all from Jasco, Japan). The Borwin PDA Controller Software (JMBS Developments, Le Fontanil, France) was used.

The column was a C18 reversed phase: Supelcosil™ LC-PAH (25 cm length;4.6 mm internal diameter; 5 µm particle size) (Supelco, Bellefonte, PA, USA),thermostated at 32.0 ± 0.2 ºC. The Borwin PDA Controller Software (JMBS Developments,Le Fontanil, France) was also used. Three solvents were used for mobilephase: 75% methanol in water (A), methanol (B) and ethyl acetate (C) with a flowrate 1 ml /min. The linear gradient program was: 0–18 min, 0–80% B in A; 18–19 min, 80–100% B in A; 19–20 min, 100–90% B in C; 20–28,5 min, 90–82% B inC; 28,5–37,5 min, 82–80% B in C; 37,5–40 min, 80–100% B in C, 40–45 min 100–0% B in A, rinsing and re-equilibration of column to the initial conditions. Excitation/emission wavelengths selected were270/390 nm for BaA andCh; 260/430 nm for BbF; 290/410 nm for BkF, BaP, DhA, and BgP; 290/470 nm for IP.The identities of the compounds were established by comparingthe retention times of the peaks with those obtained from astandard mixture of PAHs. Quantification of PAHs in meat sampleswas performed by standard addition method (using two fortified levels 10–20 ng/g).

Statistics

Two samples of each type of meat were prepared and the triplicate analysis wereperformed. Theresults were statistically analyzed by analysis of variance. Differences (ANOVA) wereconsidered significant for $p < 0.05$. Statistical analyses were all performed with SPSSfor Windows version 20 (SPSS Inc, Chicago, IL).

III. RESULTS AND DISCUSSION

PAHs formation in charcoal grilled meat

The formation of PAH8 in grilled samples ispresented in Table 1.

Table 1 - PAHs content on beef, pork and chicken charcoal grilled

	Beef	Pork	Chicken
	Mean conc. (ng/g) ± Standard deviation	Mean conc. (ng/g) ± Standard deviation	Mean conc. (ng/g) ± Standard deviation
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}	$0.39 \pm 0.39^{a,b}$	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 ($p<0.05$).

BaA, Ch, BbF, BkF, BaP, IP,BgP, DhAwere quantified at least in onetype of meat. Quantitative PAHs profiles were differentfor beef pork, and chicken. Higher levels of PAHs were found in pork, and chicken samples. EFSA [1] presented

mean barbecued meat concentrationsof BaP and PAH8 as 1.92 and 7.96 ng/g, respectively. In beef samples thesevalues 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 porkexhibited the highest amount of PAHs and muchlower amount was quantified in beef. BaP and PAH8 contentswere significantlycorrelated ($p < 0.05$) with each other and with the fat content of the raw meat (fat data was taken from INSA[4]). Fat dripsfrom 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. Results are presented inFigure 1.

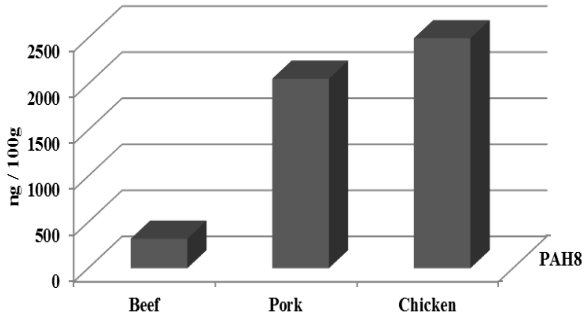

Figure 1. Intake of PAH8 expressed as ng per 100 g of cooked meat

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

IV. CONCLUSION

Chicken and pork exhibited the highest amount of PAHs and muchlower amount was quantified in lean beef. BaP and PAH8 contentswere significantlycorrelated ($p < 0.05$) with each other indicating that BaP is a good marker of the occurrence and carcinogenic potency of PAHs. Additionally, BaP and PAH8 contents were also significantlycorrelated ($p < 0.05$) with fat content of raw meat.

The consumption of charcoalgrilled fatty meat leadsto an exposure to PAHs that considerablyexceeds the estimated average intake of PAH8 across Europe and eventhe dietary exposure of high consumersestimated by EFSA[1].

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