



UNIVERSITI PUTRA MALAYSIA

**POLYCYCLIC AROMATIC HYDROCARBONS IN GRILLED BEEF
AND CHICKEN AND THEIR REDUCTION THROUGH VARIOUS
TREATMENTS**

AFSANEH FARHADIAN

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By

AFSANEH FARHADIAN

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,
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October 2010



DEDICATED TO MY BELOVED FAMILY



Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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Faculty : Food Science and Technology scope

The International Agency for research on cancer (IARC) and the Environmental Protection Agency (EPA) have classified some polycyclic aromatic hydrocarbons (PAHs) as probably and possibly carcinogenic to humans. This research has been conducted to test for availability of three of PAHs in grilled beef and chicken and assess their levels, and to evaluate the potential for reducing their levels, if any, through different treatments. The specific objectives are i) to validate the method of extraction of the PAHs (fluoranthene, benzo(b)fluoranthene and benzo(a)pyrene) from meat matrix, ii) to examine the effects of different grilling methods on generation of PAHs in meat, iii) to assess the effects of different marinating procedures on the generation of PAHs in meat, iv) to explore the effects of meat



preheating and wrapping on generation of PAHs in meat, and v) to evaluate the sensory properties of treated (marinated, preheated and wrapped) grilled meat. Tandem solid-phase extraction (SPE), were validated for sample preparation and clean up. A high performance liquid chromatography (HPLC) with fluorescence detector was used for PAHs analysis. For achievement of the second objective, nine types of Malaysian grilled meat dishes were analyzed for PAHs. The highest total concentration of the three PAHs, 103.32 ng/g, was found in the charcoal-grilled beef satay. For fulfillment of the second objective, the charcoal, gas and oven grilling methods were compared. The total concentrations of PAHs produced in the meat were significantly ($p < 0.05$) different between the three grilling methods and were 132.64 ng/g, 15.00 ng/g, and 7.14ng/g in the charcoal-, gas-, and oven-grilled dishes, respectively. Since the highest total concentrations of PAHs were detected in beef and chicken satay, these dishes were chosen for the next objectives. For third objective, seven marinade treatments at four time intervals (0, 4, 8 and 12 hr) were applied on meat samples before charcoal grilling. The study showed that the highest reductions in PAH generation were achieved by the acidic marinade treatments for the chicken (81%) and beef (70%) satay samples. Acidic marinating using lemon juice at a concentration of 1.2% for 4 hr marinating time affected significantly ($p < 0.05$) lower total PAHs generation. Therefore, this marinade treatment was applied on the meat samples in order to study the effects of preheating methods, steam and microwave heating, on reducing the duration of charcoal-grilling and PAHs generation. The results demonstrated that steam-heating lead to reductions in PAH generation ranging from 46 to 100% and from 51 to 100% respectively in the beef and chicken samples.

On the other side, microwave-heating resulted in reductions in PAH generation in the beef and chicken samples ranging from 34 to 100% and from 60 to 100%, respectively. The effects of wrapping using aluminum foil and banana leaf during charcoal-grilling on the levels of PAHs produced, Showed the reductions of PAH generation in the beef and chicken samples fell within the ranges of 39-100% and 72-100%, respectively, when aluminum foil was used as the wrapping material. However, reductions fell within the ranges of 32-100% and 81-100%, respectively, upon use of banana leaves as the wrapping material. The results of sensory evaluation confirmed that the preheating, wrapping and acidic marinating treatments were successful methods for reducing food contamination with the studied PAHs.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

**POLISIKLIK AROMATIK HIDROKARBON DALAM DAGING
DAN AYAM YANG DIPANGGANG DAN PENURUNANNYA
MELALUI PELBAGAI RAWATAN**

Oleh

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Agensi antarabangsa untuk kajian mengenai kanser (IARC) dan agensi perlindungan alam sekitar (EPA) telah mengklasifikasikan polisiklik aromatik hidrokarbon (PAHs) sebagai kemungkinan karsinogenik kepada manusia. Kajian ini telah dijalankan untuk mengkaji kedapatan bagi tiga PAHs dalam daging dan ayam yang dipanggang dan kepekatannya, serta untuk menilai potensi penurunan kepekatannya, jika ada, melalui rawatan yang berlainan. Objektif khusus ialah i) untuk menentusah kaedah pengekstrakan PAHs (fluoranthene, benzo[b]fluoranthene dan benzo[a]pyrene daripada matrik daging, ii) Untuk menilai kesan daripada pelbagai teknik memanggang terhadap pembentukan PAHs dalam daging. iii) Untuk menilai kesan



pelbagai prosedur pemerapan terhadap pembentukan PAHs dalam daging. iv) Untuk menilai kesan pra-masak dan balutan terhadap pembentukan PAHs dalam daging dan v) Menilai ciri rasa terhadap daging panggang yang dirawat (pemerapan, pra-masak dan balutan). Pengekstrakan fasa pepejal bergandingan (*Tandem SPE*), ditentusahkan bagi kaedah penyediaan sampel dan pembersihan. Kromatografi cecair berprestasi tinggi (HPLC) dengan pengesanan fluorescence telah digunakan untuk analisis PAHs ini. Untuk mencapai objektif kedua, sembilan jenis hidangan daging panggang di Malaysia telah dianalisa dengan PAHs. Jumlah kepekatan tertinggi dari tiga PAHs adalah 103.32 ng/g, yang ditemui pada sate daging yang dipanggang menggunakan bara dari pembakaran arang. Untuk memenuhi objektif kedua, Di dalam objektif kedua, kaedah pemanggangan yang berbeza dengan penggunaan arang, gas dan ketuhar telah dibandingkan. Jumlah kepekatan PAHs yang terbentuk dalam daging menunjukkan perbezaan yang ketara ($p < 0.05$) di antara tiga kaedah pemanggangan sebanyak 132.64 ng/g, 15.00 ng/g, dan 7.14 ng/g dalam hidangan yang dipanggang dengan arang, gas dan ketuhar, masing-masing. Oleh kerana kepekatan PAHs yang paling tinggi ditemui dalam sate daging lembu dan ayam, hidangan ini telah dipilih untuk kajian bagi memenuhi objektif yang seterusnya. Untuk objektif ketiga, tujuh rawatan pemerapan pada empat tempoh masa berbeza (0, 4, 8 and 12 jam) digunakan ke atas sampel daging sebelum pemanggangan dengan arang dilakukan. Kajian ini menunjukkan penurunan pembentukan PAHs yang tertinggi telah dicapai dengan rawatan pemerapan berasid bagi sampel sate ayam (81%) dan daging (70%). Pemerapan berasid dengan menggunakan jus lemon pada kepekatan sebanyak 1.2% bagi tempoh pemerapan 4 jam memberi kesan signifikan yang lebih rendah ($p < 0.05$)

terhadap jumlah pembentukan PAHs). Oleh itu rawatan pemerapan ini telah digunakan untuk sampel daging untuk mengkaji kesan kaedah pra-masak, pemanasan stim dan gelombang mikro, terhadap penurunan tempoh masa pemanggangan dengan menggunakan arang dan pembentukan PAHs. Keputusan kajian menunjukkan pemanasan menggunakan stim membawa kepada penurunan dalam pembentukan PAHs dalam julat 46-100% dan 51-100% masing-masing dalam sampel daging dan ayam. Selain itu, pemanasan dengan gelombang mikro menunjukkan hasil penurunan dalam pembentukan PAHs dalam sampel daging dan ayam dalam julat 34-100% dan 60-100% masing-masing. Kesan balutan menggunakan foil aluminium dan daun pisang semasa pemanggangan menggunakan arang terhadap kepekatan PAHs yang terbentuk, menunjukkan penurunan dalam pembentukan PAHs dalam sampel daging dan ayam dalam julat 39-100% dan 72-100%, masing-masing bila mana foil aluminium digunakan sebagai bahan balutan. Walau bagaimanapun, penurunan adalah dalam julat 32-100% dan 81-100%, masing-masing dengan penggunaan daun pisang sebagai bahan balutan. Keputusan penilaian rasa mengesahkan bahawa kaedah pra-masak, balutan dan rawatan pemerapan berasid merupakan kaedah yang berjaya untuk menurunkan pencemaran makanan dengan PAHs yang dikaji.

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I certify that an Examination Committee met on (21.10.2010) to conduct the final examination of Afsaneh Farhadian on his PhD degree of Food Science thesis entitled “Polycyclic aromatic hydrocarbons in grilled beef and chicken and their reduction through various treatments” in accordance with Universiti Pertanian Malaysia (higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The committee recommends that the candidate be awarded the PhD degree.

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DECLARATION

I declare that the thesis is my original work except for quotations and citations, which have been duly acknowledged. I also declare that it has not been previously and is not concurrently submitted for any other degree at Universiti Putra Malaysia or at any other institutions.

AFSANEH FARHADIAN

Date: 21 October 2010



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