For discussion on
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LegCo Panel on Food Safety and Environmental Hygiene

Study on Polycyclic Aromatic Hydrocarbons in Barbecued Meat

PURPOSE

This paper presents the findings of a study conducted by Food and Environmental Hygiene Department (FEHD) on polycyclic aromatic hydrocarbons in barbecued meat.

BACKGROUND

Polycyclic Aromatic Hydrocarbons

2. Polycyclic aromatic hydrocarbons (PAHs) refer to a large group of organic chemicals containing rings of carbon and hydrogen atoms. PAHs are ubiquitous in air, soil, water and foods and present as pollutants in the environment. They are formed from processing and incomplete combustion of fuels (e.g. coal, crude oil, gas etc.). Vehicle emissions and tobacco smoke are also found to contain PAHs. On the other hand, some industries manufacture PAHs for use in production of PVCs, plasticizers, dyes, etc.

Human Exposure to PAHs

3. Humans are exposed to PAHs mainly through foods contributing to about 90% of total exposure for non-smokers. For smokers, however, significant contribution of PAHs exposure may be attributed to cigarette smoking. Other minor exposure routes include inhalation of polluted air, ingestion of dust and skin absorption from contaminated soil and water.

4. As PAHs are ubiquitous in the environment, it is not surprising that they are present in almost all food, including cereals, fats and oils, and seafood. However, they are rarely found in raw foods in high levels. Cooking methods using dry heating such as roasting and grilling will generate more PAHs and result in higher levels in food. Hence, people whose diet is rich in barbecued foods may take in a larger amount of PAHs.

Health Implications

5. Though the exact mechanism of their formation in food is not precisely known, it is generally considered that incomplete combustion of the fuel used for cooking and fat disintegration in food during high temperature cooking are involved. PAHs compounds, when ingested, will undergo metabolic transformation in the human body, forming either products that are excreted, or active metabolites that are finally bind to DNA to form special compounds. The formation of these compounds is usually considered to be an initial event in chemical carcinogenesis.

6. The International Agency for Research on Cancer (IARC)[1] of the World Health Organization has classified three PAHs, namely benzo[a]pyrene, benz[a]anthracene and dibenz[a,h]anthracene, as probably carcinogenic to human (known as "Group 2A") based on evidence of carcinogenicity in experimental animals.

International Reference of Safe Intake Level

7. No international reference level for safe intake of PAHs is available. Nevertheless, as some of these PAHs may be genotoxic, i.e. toxic to the hereditary material (DNA), efforts should be made to minimise human exposure to PAHs in general as far as practicable.

SCOPE OF THE STUDY

8. Barbecued meat, popular types of traditional Chinese food in Hong Kong, is selected in this study because they had been reported to contain relatively higher level of PAHs. "Siu mei" (燒味) of "BBQ pork" (叉燒), "roasted pork" (燒肉) and "roasted duck" (燒鴨), and dried meat (肉乾) of pork and beef, prepared by various dry heating methods – charcoal/wood grilling, gas grilling and electric oven roasting/electric grilling, were chosen for this study. The objective is to assess the levels of PAHs in these food items and recommend for the trade and the public the appropriate measures that can reduce the exposure of PAHs from barbecued meat.

[1] The International Agency for Research on Cancer (IARC) is part of the World Health Orgnazisation (WHO). The Agency's mission is to coordinate and conduct research on the causes of human cancer, the mechanisms of carcinogenesis, and to develop scientific strategies for cancer control.

METHODOLOGY

9. A total of 60 siu mei (BBQ pork, roasted pork and roasted duck) and dried meat food samples prepared by charcoal/wood grilling methods (not applicable for dried meat), gas grilling and electric oven roasting / electric grilling were collected from food factories and general restaurants across the territory for PAH analysis. As comparison, raw pork and raw duck meat samples were also collected, boiled and analysed and served as control. Fifteen PAHs, including the three classified as probably carcinogenic to humans, were selected for analysis due to the concerns over their toxicity and availability of testing services locally.

10. The analysis for PAHs was done by the Food Research Laboratory of FEHD with limits of detection[2] (LODs) ranging from 0.1 to 0.7 μg/kg of food for the 15 PAHs. For each sample tested, the levels of the 15 PAHs analysed were summed up to produce a "total PAHs" while levels of the three PAHs of more concern are reported individually.

RESULTS

11. In the control samples, the three PAHs of more concern were all not detected while the total PAHs levels were also low. As for the barbecued meat samples, their PAHs levels, apart from dibenz[a,h]anthracene, were significantly higher than those in the control samples. As dibenz[a,h]anthracene was also not detected in most of the barbecued samples, a significant difference in level from the control was not observed.

12. The study results also showed that for the various cooking methods for siu mei samples, charcoal grilling gave rise to significantly higher levels of PAHs than gas grilling and electric oven roasting. For example, the median total PAHs concentrations for siu mei samples that were charcoal grilled ranged from 48.6 – 144.7 μg/kg while those for gas grilling and electric oven roasting ranged from 5.1 – 10.4 μg/kg. However, no significant difference in PAH levels was found between those being prepared by gas grilling and electric oven roasting. Lower levels of PAHs were detected in roasted duck, which were in general cooked at a lower temperature, when comparing with the other siu mei samples. The median total PAHs concentration in roasted duck, BBQ pork and roasted pork samples that were prepared by charcoal grilling were 48.6, 72.6 and

[2] The limit of detection is the smallest measure that can be detected with reasonable certainty for a given analytical procedure.

144.7 μg/kg respectively. However, the difference among them was not statistically significant.

13. Regarding the distribution of the PAHs, our results showed that in roasted ducks prepared by charcoal grilling, the "skin and fat" portion had significantly higher level of total PAHs (median concentration: 105.6 μg/kg) than the "lean meat" portion (median concentration: 2.1 μg/kg). This may be due to that the outer portion of the duck was subject to higher temperatures and was cooked at a closer distance to the heat source.

14. For dried meats, those prepared by gas grilling were found to contain significantly higher levels of total PAHs (median concentration: 138.6 μg/kg) than those prepared by electric grilling (median concentration: 82.5 μg/kg). Under similar cooking methods, dried meat was found to contain significantly higher total PAHs levels than BBQ pork (median concentrations: 10.4 μg/kg for gas grilling, 7.0 μg/kg for electric oven roasting), and this may be due to the combined effects of having larger surface area to weight ratio and having cooked at a closer distance to the heat source for dried meats.

Comparison with Overseas Studies

15. Results of the study are consistent with those reported elsewhere. However, we find PAH levels detected in our study were in general lower than those reported in other studies. It has been reported that the levels of total PAHs detected in duck meat that was cooked by roasting and charcoal grilling were as high as 130 and 320 μg/kg respectively whereas levels of total PAHs found in our roasted duck samples ranged from 3.3 to 74.9 μg/kg. This may be due to a combination of factors including the design of heating chambers of the local manufacturers which could avoid fat dripping onto the heat source.

16. The total PAHs levels in siu mei prepared by gas grilling or electric oven roasting (median levels ranged from 5.1 to 10.4 μg/kg) were comparable to those in other foodstuffs such as cereals, seafoods, oils and fats (ranged from 6 to 14 μg/kg) which were reported in overseas studies.

RISK REDUCTION

17. Results of the study showed that using charcoal grilling in preparing barbecued meat can give rise to higher levels of PAHs than using gas or electric grilling. Also, the higher the cooking temperature and the closer the distance to the heating source will result in higher levels of PAHs in the food.

18. The trade is advised to use gas grilling/electric oven roasting instead of charcoal grilling for siu mei. As for dried meat, it is preferable to prepare them by electric grilling. Manufacturers should avoid direct contact of meat with flame. They are advised to trim the visible fat from the meat and avoid dripping of fat on to the heat source. They should cook meat at a lower temperature and avoid overcooking. However the meat should be cooked thoroughly to destroy foodborne pathogens. They could also pre-cook the meat so that a lower temperature can suffice for the roasting effect.

19. Members of the public are advised not to over indulge in barbecued meat, particularly the skin and fat portions, and to remove the charred parts of the meat. They are also advised to have a balanced diet and eat more fruits and vegetables. When barbecuing, trim visible fats from meat, partially cook the meat before barbecuing and avoid the melted fat from dripping onto charcoal by putting the charcoal on sides of the stove with meat placed at the centre. They should keep meat farther from heat source but ensure that food is thoroughly cooked to destroy foodborne pathogens.

PUBLICITY

20. FEHD will later publicise the findings of the study and prepare pamphlets through various channels to advise the public and the food trade of the risk factors concerned and the ways to reduce the possible risk through barbecued meats. Reports of the study will be sent to relevant academic departments of universities and uploaded on to the FEHD Website (http://www.fehd.gov.hk) and will be available at major libraries and FEHD Communication Resource Unit and Health Education Exhibition and Resource Centre.

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