MINISTRY OF FOOD AND DRUG SAFETY
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Risk Assessment of Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic Aromatic Hydrocarbons (PAHs) are formed during the incomplete combustion of carbohydrates, fats, and proteins present in food when the food is grilled, deep-fried, or stir-fried. Benzopyrene is a PAH that is listed as “carcinogenic to humans” (Group 1) by the IARC. When PAHs are orally administrated in rats, they are rapidly absorbed *in vivo* and their bioavailability is between 20% and 50%. Research shows that the half-life of the radioactive isotope Benzo[a]pyrene (B(a)P) intravenously administered in rats is less than one minute, which means that it is eliminated quickly from the blood.

Residual hazardous substances in food that are formed during food manufacturing, processing, or cooking, and remain in the foods afterward, may pose a threat to food safety, even in small amounts, as they tend to be ingested for a lifetime. This has heightened anxiety over food safety among the Korean people. Under the existing monitoring system for hazardous substances, the content of a hazardous substance in uncooked food is measured to estimate its exposure dose based on the monitoring results. This approach fails to capture the true content of a harmful substance accurately because of changes that occur during the cooking process, where concentrations can be increased or decreased due to both physical and chemical interactions. For this reason, this risk assessment determined daily exposure doses more accurately based on a TDS, which estimates daily intakes through an analysis of table-ready foods, or an analysis of the content of hazardous substances. A quantitative assessment of potential health risks was also performed.

This risk assessment was carried out in accordance with the Regulations on Risk Assessment Methods and Procedures, as well as the Risk Assessment Guide, in the following four stages: hazard identification, hazard characterization, exposure assessment, and risk characterization.

Target foods were selected from the 2008–2013 (six years) Integrated Database, and this study covered 97.4% of the total food intake of Koreans and 98% or more of their energy, protein, fat, and carbohydrate intakes. A final set of 1,226 sample pairs was selected (291 pairs from agricultural products, 96 from livestock products, 233 from fishery products, and 606 from processed foods) after adding food commodities intended to be eaten uncooked (raw) with the "food and cooking method pairs." The analysis of PAHs present in food was performed using GC-MS, and samples of the food commodities, purchased across the country, were combined to create composite samples. One sample was analyzed for each cooking method per food, and the pair from which PAHs were not detected was considered to have a zero content.

Results of the TDS-based risk assessment show that dietary exposure to PAHs is maintained at safe levels, and that it is lower than those of the EFSA and other countries. For Korea, the average daily exposure to benzopyrene was estimated at 0.0035 μg/kg bw/day, with the average daily exposure to PAH8 at 0.0226 μg/kg bw/day. Both of these exposure levels are similar to, or lower, than those for other countries. Major dietary contributors to PAH exposure were pork, pork samgyeopsal (pork belly), and napa cabbage kimchi. Benzopyrene, which has the highest toxicity of all PAHs, was found in the highest concentrations in pork (13.0%), followed by beer (9.1%) and pork belly (8.6%). The top contributor for dietary exposure to D(a,h)A was spinach at 35.8%, whereas that for Chry was white rice at 13.2%. The food with the highest PAH content turned out to be pepper powder, although differences did exist with the cooking method used. Findings for B(a)P, D(a,h)A, B(g,h,i)P, and I(c,d)P were different from those for other PAHs. The "food and cooking method pair" with the highest B(a)P content was half-dried skipjack tuna (as is), while the pair with the highest D(a,h)A content was bulgogi sauce (as is). Bacon (pan-fried) had the highest B(g,h,i)P content, while pork belly contained the most I(c,d)P. In the case of B(a)P in particular, the top four pairs were half-dried skipjack tuna with two cooking methods (as is/scooped out after

boiling) and pepper powder, also with two cooking methods (deep-fried/stir-fried). Different types of meats were identified as next highest for B(a)P concentrations, including Korean beef sirloin (marinated–grilled), pork sirloin (pan-fried), pork picnic shoulder (grilled), pink sausage, and Vienna sausage. In the case of B(g,h,i)P, the percentage of processed meat, such as sausages and hams, in the top 10 pairs was very high. Only meat and fish/shellfish, with the exception of fried hot dogs, were included on the list of the food commodities with the highest I(c,d)P content.

In order to reduce the formation of PAHs in cooked meat, boiling is a better cooking method than roasting or grilling, and it is advisable to use a broiler for grilling meat, rather than bringing the meat into direct contact with the fire over a grate. It is best to heat the broiler before broiling the meat, and to exchange the broiler often. When meat is grilled over charcoals, the smoke will contain PAHs and should not be inhaled. Fat and meat juice should not be allowed to drip onto the charcoals. Also, the meat should not be burned; any burned parts should not be consumed.

Key words: Benzo[a]pyrene, PAHs, Foods, Risk Assessment, Total Diet Study, Reduction