MINISTRY OF FOOD AND DRUG SAFETY
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Risk Assessment of Heterocyclic Amines (HCAs)

Heterocyclic Amines (HCAs) are chemicals formed from the reaction of amino acids and creatine, or the pyrolysis of creatine when meat or fish is cooked at temperatures of 200 °C or higher. HCAs are divided into two types depending on their chemical structures: (1) amino-carbolines, which are formed in the pyrolytic reaction of pure amino acids, and (2) amino-imidazo-azaarenes, which have an aminoimidazole ring linked to a quinoline, a quinoxaline, or a pyridine. The IARC has classified imidazoquinoline as “probably carcinogenic to humans” (Group 2A) and other HCAs as “possibly carcinogenic to humans” (Group 2B).

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 Guidelines, 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 the 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 1,232 sample pairs was selected (295 pairs from agricultural products, 96 from livestock products, 233 from fishery products, and 608 from processed foods) after adding food commodities intended to be eaten uncooked (raw) to the "food and cooking method pairs." The analysis of HCAs present in foods were performed using LC-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 pairs from which an HCA was not detected were considered to have a zero content.

Although risk posed by HCAs cannot be assessed because there is no HBGV set for HCAs, there is literature available containing data on the determination of PhIP's risk. Results of applying these data to PhIP and the other HCAs indicate that dietary exposures to PhIP and A-α-C are at safe levels. The exposure doses of HCAs were estimated as follows: PhIP at 0.315 ng/kg bw/day, A-α-C at 0.188 ng/kg bw/day, harman at 150.376 ng/kg bw/day, and norharman at 474.135 ng/kg bw/day. PhIP exposure was estimated at 34.6% for pork belly (samgyeopsal), pork at 32.3%, beef at 13.6%, and cutlassfish at 5.1%. Contributors to A-α-C exposure included imported beef (50.4%), Korean beef (14.8%), pork (12.2%), samgyeopsal (10.7%), and beef byproducts (5.5%).

Case studies are available in which the exposure doses of HCAs, focusing on those potentially carcinogenic HCAs, have been assessed. Since HCAs are created in meat or fish during high-temperature cooking, target food commodities were cooked at different temperatures for different lengths of time to analyze their HCA content. The results were applied to the intake of each food commodity to estimate its exposure dose. The findings show that HCA exposure levels for Korea are 10 or more times less than those for other countries.

To reduce the formation of HCAs, it is recommended to cook food items over medium heat

(150–160 °C), rather than high heat. Food should not be overcooked to a black state, but instead, should cooked at the greatest distance possible from the heat source, and boiling and steaming should be used as cooking methods whenever possible. When meat is roasted or stir-fried, the juice of the meat should not be used to make a sauce. When charcoals are used to grill food, the food should be kept at a certain distance from them and should not come into direct contact with the flames. It is advisable to microwave the food for one or two minutes to remove the meat juice before cooking. It is also advisable to reference the following when cooking: marinating meat or fish in salt or garlic helps reduce HCA formation. Moreover, sulfur compounds (from garlic and onions) and antioxidants (e.g., anthocyanin in red wine and cherries and catechin in green tea) inhibit the formation of HCAs.

Key words: Heterocyclic amines, Foods, Risk Assessment, Total Diet Study, Reduction