MINISTRY OF FOOD AND DRUG SAFETY
National Institute
of Food and Drug Safety Evalution

Risk Assessment of Benzene

Benzene is a volatile compound found in very low concentrations in the environment, and reports indicate that it forms from the combination of vitamin C and sodium benzoate used in beverages as a preservative. In addition to vitamin C, benzene can also form in small quantities from beta-carotene, amino acids (phenylalanine, tyrosine, tryptophan), and aromatic flavonoid compounds (pinene, limonene, carene). It can also be created during the manufacturing and processing of heat-treated juices and preserved food products. Sodium benzoate is a food preservative added to prevent the formation of bacteria, yeast, and molds. It may be present naturally in some beverages. The IARC has classified benzene as "carcinogenic to humans" (Group 1). It is also known to cause anemia and platelet reduction. For most animals, benzene ingestion occurs primarily through food consumption, while excretion occurs through the respiratory system; excretion of the metabolites occurs in urine. In the case of human exposure, 12% of the exposure dose passes out of the respiratory system through the lungs in the form of benzene, while 0.1% is excreted in urine, also remaining in the form of benzene.

Residual hazardous substances 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 1,222 sample pairs was selected (289 pairs from agricultural products, 96 from livestock products, 233 from fishery products, and 604 from processed foods) after adding food commodities intended to be eaten uncooked (raw) with the "food and cooking method pairs." The analysis of benzene 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 pairs from which benzene was not detected were considered to have a zero content.

The risk of benzene in Korea was assessed against a reference dose of 4 μg/kg bw/day, which is the HBGV set by the U.S. Environmental Protection Agency. As a result of the TDS-based risk assessment for dietary exposure to benzene, risks posed by food ingestion were determined as 0.17% and 0.66% in the average exposure group and the extreme exposure group (P95), respectively. Benzene risks were also found to vary for different age groups, ranging between 0.11% and 0.82%. This shows that benzene risks are being managed at safe levels. Exposure levels of benzene in Korea are lower than those in other countries, and results of this study showed that they are even lower now than from a previous research project implemented by the Ministry of Food and Drug Safety (MFDS) in 2013. The average detection rate for benzene in food was 27.5%. It was 57.9% for fishery products, 35.4% for

livestock products, 17.6% for agricultural produce, and 19.4% for processed foods. The food and cooking method pairs with high benzene content included dried green laver (stir-fried), half-dried skipjack tuna (as is), deep-fried kelp (as is), roasted laver (as is), and dried whitebait (stir-fried), in that order, with most of the foods on the list being seaweeds and fish/shellfish. The daily exposure dose per Korean person was 6.935 ng/kg bw/day. Major contributors to dietary benzene exposure were pork belly (15.7%), mackerel (13.8%), pork (7.5%), anchovy (dried after boiling, 7.3%), Pacific saury (4.4%), laver (4.0%), chicken (3.4%), sesame oil (2.7%), oysters (2.4%), and instant coffee (powder, 2.4%).

As mentioned previously, benzene can form in small quantities when both vitamin C and sodium benzoate are present in beverages. For this reason, in 2006, the food and beverage industry was urged by the MFDS to improve production methods. Examples included using an alternative preservative other than sodium benzoate or replacing it with a natural preservative. The ministry also controls benzene use by issuing instructions for strengthening internal quality inspection procedures. Currently, benzene exposure is controlled at safe levels, but it is necessary to continue to monitor and control exposure levels according to the as low as reasonably achievable (ALARA) principle because benzene is a carcinogen that can form from the reaction of vitamin C with naturally derived sodium benzoate in foods, as well as artificially during food manufacturing and processing.

Key words: Benzene, Foods, Risk Assessment, Total Diet Study, ALARA, Reduction