Distribution and contents of gallium (Ga), arsenic (As) and the trace elements (Sr, Cs, Co and V) in rice grains and the risk assessment of As

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Abstract

Rice is the world's second largest crop as well as a staple food for half of the global population. Recently, the trend of eating whole grains has raised due to the health benefits. The bran, which is part of the brown rice and colored rice, is rich in phytochemicals, vitamin B complex, dietary fiber and trace elements. In Taiwan, the high-tech industry and agriculture are both well-developed. Because of the planting environment, the toxic elements might uptake from the rice plant roots during growing stages, then accumulate them in the harvested rice grains. Inorganic arsenic (As) is proved carcinogenic and is a Group 1 carcinogen. Gallium (Ga), is one of the metals that is used in the semiconductor industry in Taiwan, and its related research to environment and human health are still few. The objective of this study is to determine the distribution and accumulation of Ga, As and other trace elements in the rice grains. Firstly, 29 paddy rice samples from selected origins, including 15 japonica, 3 indica and 11 colored rice were fractionated into paddy, husk, brown rice, bran and polished rice. Moisture and ash contents were determined and inductive coupled plasma-mass spectrometry (ICP-MS) was used to determine the contents of Ga and As. Secondly, 69 commercial rice samples were purchased from local markets and the contents of elements of Ga, As, strontium (Sr), cesium (Cs), cobalt (Co) and vanadium (V) were determined. The results showed that the average moisture contents (11.02-13.67%) of rice grains were similar among each fraction. The

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trend of ash contents was husk (14.35%) > bran (9.12%) > paddy rice (4.76%) > brown rice (1.49%) > polished rice (0.70%). The trend of Ga contents was husk (1.431 mg/kg) > bran (1.079 mg/kg) > brown rice (0.144 mg/kg) > polished rice (0.074 mg/kg) while the bran (1.00 mg/kg) had the highest content of As. In the 69 commercial rice samples, As was detected in all of the samples and the contents in brown rice were significantly higher than polished rice. Co and Cs were detected in one-third samples. The range of contents of As, Co and Cs were 0.048-0.773, <LOQ (limit of quantitation)-0.267 and <LOQ-0.162 mg/kg, respectively. Sr and Ga were only detected in four and two colored rice, respectively. The contents of V in rice samples were all below LOQ. The non-cancer and cancer risk assessments of As at each age group were based on the As contents of commercial rice samples and the data of National Food Consumption Database in Taiwan. It was indicated that the non-cancer risk was in all age groups. Cumulative cancer risk was higher than 1×10^{-4} The contents of As in rice and the healthy risk should be continuously considered in the future.

Keywords: Arsenic (As); gallium (Ga); trace element; rice; risk assessment