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Heavy metal analysis of wild edible mushrooms grown in Türkiye and assessment of possible carcinogenic and non-carcinogenic risk

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ABSTRACT

In this study, heavy metals (HM) composition of in seventy-three wild edible mushroom (WEM) species collected from unpolluted areas in fourteen provinces of Türkiye was determined by X-ray fluorescence spectrometry. The concentrations of Cr, Mn, Fe, Co, Ni, Cu, Zn, Zr, Cd, Hg, Pb and As analyzed in WEM species varied from 1.1 to 76.3, 13.8–822.7, 9.5–8867.0, < 3.0–31.8, 5.1–44.4, 3.8–380.2, 17.9–912.0, < 0.5–19.5, < 0.8–4.9, < 0.9–15.6, < 0.8–31.9 and < 0.5–257.4 mg/kg dry weight, respectively. The concentrations of Cd and Pb were higher than the limits recommended by the Turkish Food Codex for cultivated mushrooms. The potential carcinogenic and non-carcinogenic risks caused by the ingestion of WEM species containing HMs were assessed by estimating the hazard and total cancer risk index. Non-carcinogenic risk assessment reveals no risk for consumption of the studied WEM species for adult consumers, except for two WEM species. On the other hand, 26 % of the values of the total cancer risk index assessed for Cr, As, Pb, and Ni in WEM species exceed the acceptable limit ($\geq 10^{-4}$).

1. Introduction

Heavy metal(loids) (HMs) are elements specified by toxicity to living organisms and high densities that are approximately five times the water density (Mitra et al., 2022; Abd Elnabi et al., 2023). HMs are well-known important environmental pollutants because they are not biodegradable, long-lived in the environment, and can accumulate in the human body through bioaccumulation (Tchounwou et al., 2012; Mitra et al., 2022; Das et al., 2023; Abd Elnabi et al., 2023; Aziz et al., 2023). Therefore, pollution or contamination of the environment (water, soil, plants, etc.), air, and food with HMs has become a serious, vital, and global problem of great concern for ecology and human health (Balali-Mood et al., 2021: Vaziri et al., 2021; Mitra et al., 2022; Das et al., 2023; Aziz et al., 2023; Ehtemae et al., 2023; Upadhyay et al., 2024). HMs exist naturally in the Earth's crust. However, the introduction of HMs into the environment, atmosphere, and food chain can originate from natural processes (atmospheric deposition, weathering of rocks, leaching of heavy metals, sediment re-suspension, metal corrosion, erosion of metal ions in the soil, volcanic eruptions, etc.) and anthropogenic activities (power plants, mining. metal processing, foundries and smelters, metallurgy, electroplating, fertilizer and pharmaceutical production, agriculture, textile, leather tanning, other chemical industries, household waste, etc.) (Tchounwou et al., 2012; Balali-Mood et al., 2021; Mitra et al., 2022; Das et al., 2023; Abd Elnabi et al., 2023; Aziz et al., 2023). HM pollution is one of the most critical global environmental problems that directly or indirectly endangers the lives of almost all living species and reduces crop productivity and biodiversity (Das et al., 2023). HMs are classified as either essential or non-essential metals according to their functions in biological systems (Abd Elnabi et al., 2023). Varying amounts of essential HMs such as iron (Fe), cobalt (Co), zinc (Zn), copper (Cu), and manganese (Mn) are indispensable for living organisms (Singh et al., 2011). However, even low concentrations of non-essential HMs such as cadmium (Cd), mercury (Hg), arsenic (As), lead (Pb), chromium (Cr), and nickel (Ni) pose a significant threat to living organisms due to their toxicity characteristics (Das et al., 2023). Long-term exposure of humans to essential or non-essential HMs through ingestion of contaminated foods, inhalation, and skin contact may cause physiological or morphological disorders or mutagenic reactions resulting in cancer (Tchounwou et al., 2012; Abd Elnabi et al., 2023; Das et al., 2023). Therefore, consumers must be protected against high levels of HMs in foodstuffs by regulating them to the limit values specified in the framework of national and international regulations (Kollander et al.,

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