



Assessment of radioactivity levels and radiological health risks of commercial medicinal and aromatic herbs consumed in Türkiye

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ABSTRACT

The raw parts (roots, leaves, seeds, flowers, etc.) and extracts of medicinal and aromatic herb (MAH) species are widely utilized in traditional and modern medicine as drugs to treat disease and/or prevent illnesses. MAH species absorb nutrients and minerals from the soil, as well as toxic elements and radionuclides dispersed in the environment. Thus, this may provoke concerns about the possibility of human internal exposure to radionuclides found in these MAH species. This study aims to create a detailed database related to the activity concentrations of the natural (^{228}Ra , ^{226}Ra , and ^{40}K) and artificial (^{137}Cs) radionuclides in popular commercial MAH species consumed in Türkiye and potential radiological health risks (PRHRs) due to the ingestion of MAHs. The activity concentrations (Bq/kg) of the radionuclides analyzed in the commercial popular 98 MAH samples by a gamma-ray spectrometric method varied from <0.6 to 19.3 with an average of 6.9 (^{228}Ra), <0.5 to 37.5 with an average of 8.6 (^{226}Ra), and 32 to 1297 with an average of 358 (^{40}K). All activity concentrations of ^{137}Cs were found below 0.3 Bq/kg. The average values of total annual effective dose, mortality cancer risk, and morbidity cancer risk estimated for adult consumers to assess PRHRs were found to be 16.5 $\mu\text{Sv/y}$, 6.0×10^{-5} and 8.9×10^{-5} , respectively. This study reveals that radiological data are below acceptable limits for public health, and therefore, the studied MAH samples are safe in terms of radiological risk.

1. Introduction

Medicinal and aromatic herb (MAH) species are fundamental natural sources with applications in various industries such as medicine, food, cosmetics, perfumes, pharmaceuticals, flavorings, chemicals, dyes, pesticides, etc. (Zamani et al., 2025). The utilization of MAH species as medicines for the treatment and/or prevention of illnesses is an ancient practice known as traditional medicine, as old as human history (Sussa et al., 2013). The World Health Organization (WHO) has promoted the use of traditional medicine worldwide by encouraging the integration of its beneficial components into national health systems (Popoola et al., 2024). Thus, today, the utilization of some MAH species has been scientifically proven by modern medical methods, pharmacists, and molecular biologists, and has been reintroduced to human life with the approval of relevant authorities (Cengiz and Çağlar, 2019). Furthermore, according to a WHO, 2019, approximately 80 % of the global population in 170 countries utilizes traditional practices such as

acupuncture, herbal medicines, Ayurveda, and local therapies. Traditional medicine often serves as a first-line treatment, particularly for chronic diseases (Zamani et al., 2025). Also, approximately 40 % of modern pharmaceutical products, including artemisinin, aspirin, and childhood cancer treatments, are obtained from natural sources and traditional knowledge (Kırış, 2022; Zamani et al., 2025). Furthermore, plant-derived active ingredients constitute approximately 25 % of prescription drugs in developed countries (Kırış, 2022; Zamani et al., 2025). Approximately 20,000 plants are widely utilized for medicinal purposes worldwide (Monica et al., 2020). Thanks to its geographical location and genetic diversity, Türkiye's flora displays diversity and richness of over 10,000 identified plant species, comparable to the total number of plants found in all of Europe (Pakdemirli et al., 2021). Türkiye has approximately 500 MAH species, and Turkey is a major partner for many countries demanding MAH products (Pakdemirli et al., 2021).

MAH species contain a broad spectrum of chemical compounds such as terpenoids, volatile oils, phenolic compounds, alkaloids,

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