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NATURAL AND ARTIFICIAL RADIONUCLIDES IN HERBAL TEAS

Jelena Ajtić*, Branislava M. Mitrović

Faculty of Veterinary Medicine, University of Belgrade, Serbia

Abstract. *Due to their therapeutic and pharmacologic properties, medicinal herbs have a long history of use around the world. The objective of this study is to determine the activity concentration of natural (^{40}K, ^{226}Ra, ^{232}Th, and ^{238}U) and artificial (^{137}Cs) radionuclides in samples of herbal teas from Serbia. The samples of the following commercially available teas: dandelion leaf (Taraxaci folium), mulberry leaf (Mori nigrae folium), ground ivy (Glechoma hederacea), sweet wormwood (Artemisia annua), rose hip (Cynosbati fructus), wall germander (Teucrium chamaedrys), and thyme (Thymus vulgaris), were collected in Serbia in 2021. The radionuclides' activity concentrations were determined using gamma spectrometry. The results show that among the natural radionuclides, ^{40}K is dominant (320–1600 Bq/kg), while the activity concentration of ^{226}Ra and ^{232}Th ranges from below the minimum detectable activity (MDA) to 12 Bq/kg, and below the MDA to 13 Bq/kg, respectively. In all investigated samples, the ^{238}U activity concentration is below the MDA. Cesium-137 is detected in five out of seven analysed samples (MDA–2.9 Bq/kg). The results indicate that ^{137}Cs, released into the atmosphere after the Chernobyl accident in 1986, is still present in the environment of Serbia. Nevertheless, according to the Serbian legislation regulating the maximum permitted levels of radionuclides in foodstuffs, all of the investigated samples of herbal teas are safe for human consumption.*

Keywords: *gamma spectrometry, herbal tea, radionuclides, Serbia*

1. INTRODUCTION

Ingestion of food and water is the main route of radioactive input in the human body. Natural radionuclides (e.g., ^{40}K, ^{226}Ra, ^{232}Th, and ^{238}U) have been present in the environment from the formation of the Earth, and they are typically present in food [1-3]. The primary source of the artificial radionuclide ^{137}Cs found in the environment of Serbia is the nuclear accident in Chernobyl (1986); due to a great distance, the accident in Fukushima (2011) did not contribute to the environmental contamination in Serbia [4, 5].

Radionuclides present in the environment are taken up by the plants primarily via root, and their concentration in different plant parts varies as a consequence of their translocation [6, 7]. The content of natural and artificial radionuclides in the soil, as well as the soil physico-chemical characteristics [8] and physiological and morphological properties of plants, affect the radionuclide content in plants. In addition to the radionuclides, herbal teas can be a source of other contaminants such as pesticides, mycotoxins, microorganisms and heavy metals [9]. Previous studies have shown that the contaminants from herbal teas are generally transferred to tea infusions in small quantities, making the infusions safe for human consumption [7, 9, 10].

The aim of this study was to determine the activity concentration of natural (^{40}K, ^{226}Ra, ^{232}Th, and ^{238}U) and artificial (^{137}Cs) radionuclides in samples of herbal teas from Serbia, and to compare the obtained results with available literature data.

2. MATERIALS AND METHODS

The samples of commercial herbal teas were collected from different regions in Serbia during 2021, and analysed by gammaspectrometric method. Prior to the analyses, the collected samples were homogenized and transferred into Marinelli beakers volume 0.5 l.

For the detector efficiency calibration, milled grass reference material (containing the following radionuclides ^{241}Am, ^{109}Cd, ^{139}Ce, ^{57}Co, ^{60}Co, ^{137}Cs, ^{85}Sr, ^{88}Y, ^{51}Cr) was used. The samples and the background were measured for 240000 s. Analysis of the measured gamma spectra was performed using GAMMA VISION® 32 (Ortec, USA) software.

The minimum detectable activity (*MDA*) (Table 1) was determined for each radionuclide using [11]:

$$\mathrm{MDA}=4.65 \cdot \frac{\sqrt{B}}{LT} \qquad (1)$$

where B is background reported in the identified peak summary (counts), and LT is live time (in seconds).

Table 1. The minimum detectible activity of radionuclides.

Radionuclides (Bq/kg)				
^{40}K	^{238}U	^{226}Ra	^{232}Th	^{137}Cs
0.8	5.5	4.8	1.0	0.2

* jelena.ajtic@vet.bg.ac.rs

3. Results and discussion

The activity concentration of the natural (^{40}K, ^{226}Ra and ^{232}Th) and artificial (^{137}Cs) radionuclides in seven commercial herbal teas are presented in Table 2. In all investigated samples of herbal teas, the activity concentration of ^{238}U was below the *MDA*, and the ^{238}U results are not given in Table 2.

Table 2. The activity concentration of radionuclides in commercial herbal tea.

Herbal tea	Latin name	Radionuclides (Bq/kg) ^{40}K	^{226}Ra	^{232}Th	^{137}Cs
Dandelion leaf	*Taraxaci folium*	1600-±100	< *MDA*	< *MDA*	2.9 ± 0.4
Mulberry leaf	*Mori nigrae folium*	780 ± 40	< *MDA*	< *MDA*	< *MDA*
Ground Ivy	*Glechoma hederacea*	990 ± 90	6 ± 1	6 ± 1	0.6 ± 0.1
Sweet wormwood	*Artemisia annua*	1100 ± 90	< *MDA*	1.2 ± 0.3	0.3 ± 0.1
Rose hip	*Cynosbati fructus*	320 ± 20	7 ± 1	< *MDA*	0.3 ± 0.1
Wall germander	*Teucrium chamaedrys*	660 ± 40	10 ± 2	13 ± 2	0.4 ± 0.1
Thyme	*Thymus vulgaris*	670 ± 50	12 ± 2	11 ± 1	< *MDA*

The natural ^{40}K was the dominant radionuclide in the herbal teas (with the average of 874 Bq/kg); its minimum activity concentration was detected in Rose hip (320 Bq/kg) and maximum in Dandelion leaf (1600 Bq/kg). The average activity concentration of ^{226}Ra and ^{232}Th in the herbal teas were 8.8 Bq/kg and 7.8 Bq/kg, respectively. As already mentioned, the content of ^{238}U was below the detection limit. The variation in the content of natural radionuclides in herbal teas is a consequence of a number of factors: differences in plant species, presence of radionuclides in the soil, and their availability for resorption to plants via root. The obtained results for ^{238}U, ^{232}Th and ^{40}K are in line with published data on the content of radionuclides in medicinal herbs in Serbia [12].

Further, similar results were detected in medicinal plants in India [13]: activity concentration of ^{226}Ra varied from 2.7 Bq/kg to 11.3 Bq/kg, with the mean of 6.3 Bq/kg, which is in line with our results. On the other hand, the ^{232}Th activity concentration (ranged from 2.4 Bq/kg to 8.7 Bq/kg) was slightly higher in our study.

The artificial radionuclide ^{137}Cs was detected (*MDA*–2.9 Bq/kg) in five of the seven investigated samples. The variation of the ^{137}Cs content in plants is a consequence of different soil contamination and geochemical characteristics, meteorological conditions, plant species and growing conditions [10]. A similar content of ^{137}Cs in herbal teas from different regions of Serbia, except for blueberry tea, has been reported in a study that investigated fifteen samples of herbal teas (collected in 2018) and found that the activity concentration of ^{137}Cs ranged from below *MDA* to 24.7 Bq/kg that was measured in blueberry tea [7].

For comparison, a much higher average content of ^{137}Cs (42 Bq/kg) was found in black and green tea from Turkey [2], but the tea infusion did not present a risk for humans.

4. Conclusion

Gammaspectrometric analysis of the herbal teas from Serbia showed that the activity concentrations of natural radionuclides ^{40}K, ^{238}U, ^{226}Ra and ^{232}Th agreed with the data published for Serbia and other parts of world. The artificial ^{137}Cs is still present in small quantities in the environment of Serbia. Our results thus indicate that the investigated herbal teas were safe for human consumption.

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