RADIONUCLIDE CONTENT IN *MATRICARIA CHAMOMILLA L.*, GROWN IN TWO REGIONS

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ABSTRACT

This article analyses the content of natural radionuclides in chamomile plants collected from two different locations. Both samples have been dried in the shade at room temperature.

The chamomile has been collected in July 2016 from two different regions of Bulgaria - Yagnilo village, Varna district and the village of Debeli Rat, Veliko Tarnovo district. They are dried under natural conditions and milled into a fine powder. The measurements are taken on a low-background spectrometer at Shumen University "Episkop Konstantin Preslavski". The resulting gamma-spectra are processed with ANGES software. Radioisotopes are determined by their energies. The values of their specific activities are calculated. Approximately the same levels of ^{226}Ra, ^{228}Ac, $^{208}T1$ and ^{40}K are found in the samples from both regions.

The highest levels of radionuclides are measured for ^{40}K, the lowest specific activity in the flowers from Yagnilo is found for ^{208}Tl, and in those from Debeli Rat – for ^{212}Pb. The levels of their specific activities are within the limits, according to Ordinance №25 on the requirements for protection of people in case of chronic irradiation, as a result of production, trade and use of raw materials, products and goods with increased content of radionuclides and Ordinance №11 on defining the terms and conditions for providing free food and/or supplements to the workers and employees who work in enterprises of a specific nature and organization of work. The public health of consumers is not at risk, given these levels.

Keywords: *gamma–spectrometry, chamomile, natural radionuclides, specific activity*

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INTRODUCTION

Chamomile is a herbaceous plant. It is 10 - 30 cm in height, with erect, branching stems and alternate, tripinnately divided leaves below and bipinnately divided leaves above, both types having almost filiform lobes. The capitulum (to 1.5 cm in diameter) comprises 12 - 20 white ligulate florets surrounding a conical hollow receptacle on which numerous yellow tubular (disk) florets are inserted. The inflorescence is surrounded by a flattened imbricated involucre. The fruit is small, smooth, yellowish (1).

Chamomile contains various types of biologically active substances, including triterpenes, flavonoids, hydroxycoumarines, essential oils, glycosides, and haemazulen and α-bizabolol, which are very significant in delivering a therapeutic effect. It is mainly used as dry flowers in tea preparation. A study investigated the use of chamomile flowers for medical tea preparation, ointments, mouthwashes, solutions for rinses and inhalations, lotions, etc. These remedies are useful in case of inflammation of the mucous membranes, gingivitis, parodontitis, anovaginal inflammation, cold and flu conditions and as immunostimulants (2, 3).

PROBLEM DISCUSSION

Nowadays, the consumption of chamomile tea from flowers, home-dried or purchased from the market, is widespread. The market herbs are of unknown origin and thus, an unknown concentration of radionuclides. As the radioisotopes are being absorbed from the soil and the atmosphere (4), this proves a substantial indicator of the ecological state of the herb from its gamma-spectrometric analysis. The close evaluation of its result can thereby be used to establish a safe parameter for its use, dependent on its radionuclide content.

The natural sources of radioactivity ^{238}U, ^{226}Ra, ^{232}Th and ^{40}K and their daughter chain products have a great impact on the human body. These are the radionuclides that are taken into account when assessing the dose load on the person. Of the technogenic radionuclides the most common are ^{137}Cs and ^{90}Sr. Plants particularly transfer these to the human body, resulting in increased levels of internal irradiation. The World Health Organization underlines that the health risk is dependent on the amount of radionuclide content within the herbs as well as on the dose and duration of intake (5).

AIM

The aim of the study is to evaluate the radionuclide content in randomly collected chamomile flowers grown in ecologically clean areas at different altitudes. The content of radionuclides in herbs makes it possible to assess the level of safety in the use of herbal substances as well as to assess the radiological contamination in the relevant area.

MATERIALS AND METHODS

The altitude induces an effect on the level of contamination of plants with cosmogenic radionuclides. This is explained by the protective properties of the Earth's atmospheric layer. As the altitude increases, the protective function of the atmosphere against the cosmic radiation background decreases. The best radiation protection is observed at the sea level where the thickness of the Earth's atmosphere is the greatest. For this reason, we chose regions with different altitudes in Bulgaria - the village of Yagnilo, Vetrino township, Varna district, located at altitude of 251 m and the village of Debeli Rat, Veliko Tarnovo district – at altitude of 565 m.

The chamomile flowers were collected in July 2016 from both regions, dried at room temperature and milled into a fine powder. The samples, thus obtained, are subjected to gamma-spectrometric analysis. For this purpose, low-background gamma-spectrometric unit has been used. It is located in the Laboratory of Nuclear Physics and Radioecology of the Shumen University "Episkop Konstantin Preslavski". The unit includes a gamma-quantum Ge(Li) detector with a cooling system and high voltage block, preamplifier, linear pulse amplifier, digital converter, multi-channel amplitude analyzer and computer. The detector has a crystal volume of 60 cm^3, a working voltage of 1 kV and a relative efficiency of 4.5% for the gamma-line of ^{137}Cs with an energy of 661.66 keV (6). It is located in a "protective camera" with combined protection of 100 cm of lead, 5 cm of aluminum and 1 cm of cadmium. It is designed to measure low active samples and reduce the background radiation from the environment. Gamma-spectra are collected for 86400 s and processed with special software – ANGES.

For the energy calibration of the system, certified reference sources are used with precise measurement of quantum energy (calibration sources), which produce a calibration spectrum. Calibration sources are selected so that gamma-line energies can accurately describe the entire energy range in which the energies of the unknown set of sources are located. Typically used calibration sources are ^{137}Cs (E =

661.66 keV) and ^{60}Co (E_1 = 1173.23 keV; E_2 = 1332.50 keV.

The intensity of the radiation is detected by the detector and processed by computer software "SpectLab", which generates an energy spectrum. The resulting spectrum is processed with the computer program "ANGES". This enables the measurement of the width of the photopeaks and the intensity of the radiated gamma-quanta and their permissible errors. As a result, text files with information on the emitted energies are obtained, quantifying the radionuclide content of the samples tested. From this data, we can now calculate the activity and specific activity of natural radionuclides by using the following formulas (6).

Activity is calculated by Formula 1:

$$A = \frac{Sn}{(\varepsilon I.t)}[Bq], \quad (1)$$

where:

A – activity [Bq];
S_n – peak area;
ε – effectiveness [%];
I – intensity [keV];
t – live time [s].

Specific activity is calculated by Formula 2:

$$A\% = \frac{A}{m}\left[\frac{Bq}{kg}\right], \quad (2)$$

where:

A% is specific activity;
A is activity [Bq];
m - mass [kg].

Radionuclides from the uranium-radium and thorium families – ^{226}Ra, ^{212}Pb, ^{214}Pb, ^{228}Ac, ^{214}Bi, ^{208}Tl, ^{40}K **(Table 1)** are found in both samples. The highest values are measured for ^{40}K - a radionuclide of cosmogenic origin, which is absorbed directly from the shoot system of the plants. ^{40}K is also known as cosmogenic dust. Its values are significantly higher in the samples of Debeli Rat, which may be due to the higher altitude of 565 m and the reduced thickness of the atmospheric layer. The method of drying in shade at room temperature is widespread among herbalists and citizens but this may also result in the accumulation of dust on the samples while drying.

Table 1. Specific activities of natural radionuclides in chamomile

Radionuclides	A_{sp} [Bq/kg]	
	Chamomile–village of Yagnilo	Chamomile–village of Debeli Rat
^{226}Ra	294±44	235±35
^{212}Pb	61±9	39±6
^{214}Pb	-	40±6
^{228}Ac	172±26	123±19
^{214}Bi	56±8	74±11
^{208}Tl	51±8	60±9
^{40}K	2020±303	2130±320

In both samples a high specific activity of ^{226}Ra and ^{228}Ac is detected. There is no ^{214}Pb in the sample from the village of Yagnilo, which is seen to be present in the other sample. The lowest specific activity in Yagnilo sample is for ^{208}Tl (51 Bq/kg), and in Debeli Rat – for ^{212}Pb (40 Bq/kg). The highest specific activity in the chamomile collected in the area of the village of Yagnilo is detected for ^{226}Ra, ^{212}Pb and ^{228}Ac, and in the area of the village of Debeli Rat - for ^{214}Bi and ^{208}Tl.

Low specific activity in the plant of Yagnilo is detected for $^{208}T1$ (51 Bq/kg), and in the plant from Debeli Rat – for ^{212}Pb (39 Bq/kg).

The results obtained for the two samples do not differ significantly and are similar within the experimental error. They do not exceed the maximum permitted levels in the chamomile collected in these two regions (while dried under natural conditions).

CONCLUSION

As a result of the analysis of data from the chamomile samples collected from two different altitudes and dried at home at room temperature, we can draw the following conclusions:

1. The content of radionuclides found in both samples has similar qualitative composition.
2. In both plants, a higher specific activity of ^{40}K, ^{226}Ra and ^{228}Ac is measured, compared to other radionuclides.
3. Radionuclides of technogenic origin are not detected.
4. The values for the specific activities of the radionuclides found in the samples are compared to the maximum permitted levels. This gives us reason to conclude that the radiological risk associated with the use of medicinal plants containing radionuclides is absent, in reference to Ordinance № 11 and Ordinance № 25.

The levels of the specific activities of the natural radioisotopes are within the limits of Ordinance №25 for the protection of people exposed to chronic radiation using materials with increased content of radionuclides (prom., SG, № 64/2005).

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