doi:10.46793/ICCBI21.145Z

RADIOACTIVITY ASSESSMENT OF NATURAL RADIONUCLIDES AND ^{137}Cs IN COMMONLY CONSUMED FOODS

Milena P. Živković[1], Dragoslav Nikezić[1,2], Tatjana B. Miladinović[3], Jelena M. Stajić[3], Dragana Ž. Krstić[1]

[1] University of Kragujevac, Faculty of Science, R. Domanovica 12, 34000 Kragujevac, Republic of Serbia
e-mail: milena.zivkovic@pmf.kg.ac.rs, dragana.krstic@pmf.kg.ac.rs, nikezic@kg.ac.rs
[2] The State University of Novi Pazar, Novi Pazar, Serbia
e-mail: nikezic@kg.ac.rs
[3] Institute for Information Technologies, University of Kragujevac, Jovana Cvijića bb, 34000 Kragujevac, Serbia
e-mail: tanja.miladinovic@uni.kg.ac.rs, stajicjelena11052012@gmail.com

Abstract:

The goal of this research is to determine the levels of natural and artificial radioactivity in 13 different samples of commonly consumed foods from Serbian markets. A gamma spectrometry was used to measure the activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K, and ^{137}Cs. The annual whole-body doses from ^{137}Cs and natural radionuclides, due to the consumption of tea for an adult, are in the range of 2.3–8.5 nSv for ^{137}Cs, 14.1 - 21.7 nSv for ^{232}Ra, 18.4 - 73.6 nSv for ^{232}Th and for ^{40}K 10.4 - 22.9 nSv. These doses are not harmful to the general public's health.

Keywords: gamma spectrometry, radioactivity concentrations, daily food, tea

1. Introduction

Updating understanding and assessing the consequences of radiation exposure and associated hazards are critical nowadays. In Serbia, tea, flour, rice, powdered milk are often utilized, and their consumption is increasing. Radionuclides such as ^{40}K, ^{232}Th, ^{137}Cs and ^{226}Ra pose a threat if they are found in human cells [1]. The consumption of food items accounts for about one-eighth of the population's radiation exposure [2]. Chemical properties of radionuclides are similar to those of nutrients, and they are absorbed by plants together with the nutrients required for their growth [3]. The assessment of gamma radiation exposure from natural sources is critical since natural radiation provides most of the external dose to the global population [4].

The purpose of this study is to estimate the activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K, and ^{137}Cs in 13 different samples of regularly consumed products commercially available in Serbian markets, as well as to calculate the yearly whole-body dose of radionuclides for an adult who consumes herbal teas.

2. Material and methods

2.1 Collection and preparation of samples

Thirteen samples were purchased at a health food store and market. To make a homogenous powder, the samples were dried and crushed with a mill. The powder was filtered through a sieve. Then they were placed in Marinelli bakers where each baker was specially marked. During the final stages of preparation, the samples were hermetically sealed for a period of four-to-six-weeks to achieve a secular equilibrium between ^{226}Ra and its short-lived decay products.

2.2 Gamma spectrometry

The activity concentrations of ^{226}Ra, ^{232}Th, ^{40}K and ^{137}Cs were measured using coaxial HPGe detector (GEM30-70, ORTEC) with a relative efficiency of 30 % and energy resolution (FWHM) of 1.85 keV at 1.33 MeV (^{60}Co). The detector was housed inside a 10 cm lead shield to reduce the background. To measure the activity, a timer was set to 172800 seconds and a background correction was made. Spectrum analysis was done by using the computer software MAESTRO 2. The activity concentration of ^{226}Ra was obtained using the gamma lines of ^{214}Pb and ^{214}Bi (351.9 keV, 609.3 keV and 1764.5 keV). The specific activity of ^{232}Th was estimated through the gamma lines at 338.3 keV, 911.1 keV, and 583.0 keV (^{228}Ac and ^{208}Tl). ^{137}Cs activity concentration was estimated by observing the gamma line at the energy of 661.6 keV. The photopeak at 1460.7 keV was used for estimating activity concentration of ^{40}K in samples.

2.3 Activity concentration and annual effective dose of herbal tea

Specific activity of radionuclides can be calculated as [5]:

$$AC = \frac{N_L}{e \times m \times t \times P_g}, \tag{1}$$

where: AC is the activity concentration (Bq kg^{-1})
N_L the net area of the photopic
m is the sample mass (kg)
e counting efficiency for a specific energy
P_g is the emission probability of the measured gamma-ray
t is the counting time (s).

The annual effective dose of herbal tea is calculated using equation [6]:

$$E_{ing} = CHDF_{ing}, \tag{2}$$

where E_{ing} is the annual effective dose of tea intake (Sv year^{-1}), C is the concentration of radionuclides in the product (Bq kg^{-1}), H is the rate of tea consumption per year (kg year^{-1}) and DF_{ing} is dose coefficient for ingestion (Sv Bq-1 (Sv Bq^{-1}).

3. Results and discussion

Activity concentrations of natural radionuclides (^{226}Ra, ^{232}Th, and ^{40}K) measured in food samples are presented in Fig. 1. ^{40}K was present in all samples in a wide range of concentrations from 16 to 1250 Bq kg^{-1} (with the highest levels being measured in tea herbs). On the contrary, activity concentrations of ^{226}Ra and ^{232}Th were rather low in all samples. Artificial radionuclide ^{137}Cs was detected only in tea herbs in low levels (<1 Bq kg^{-1}).

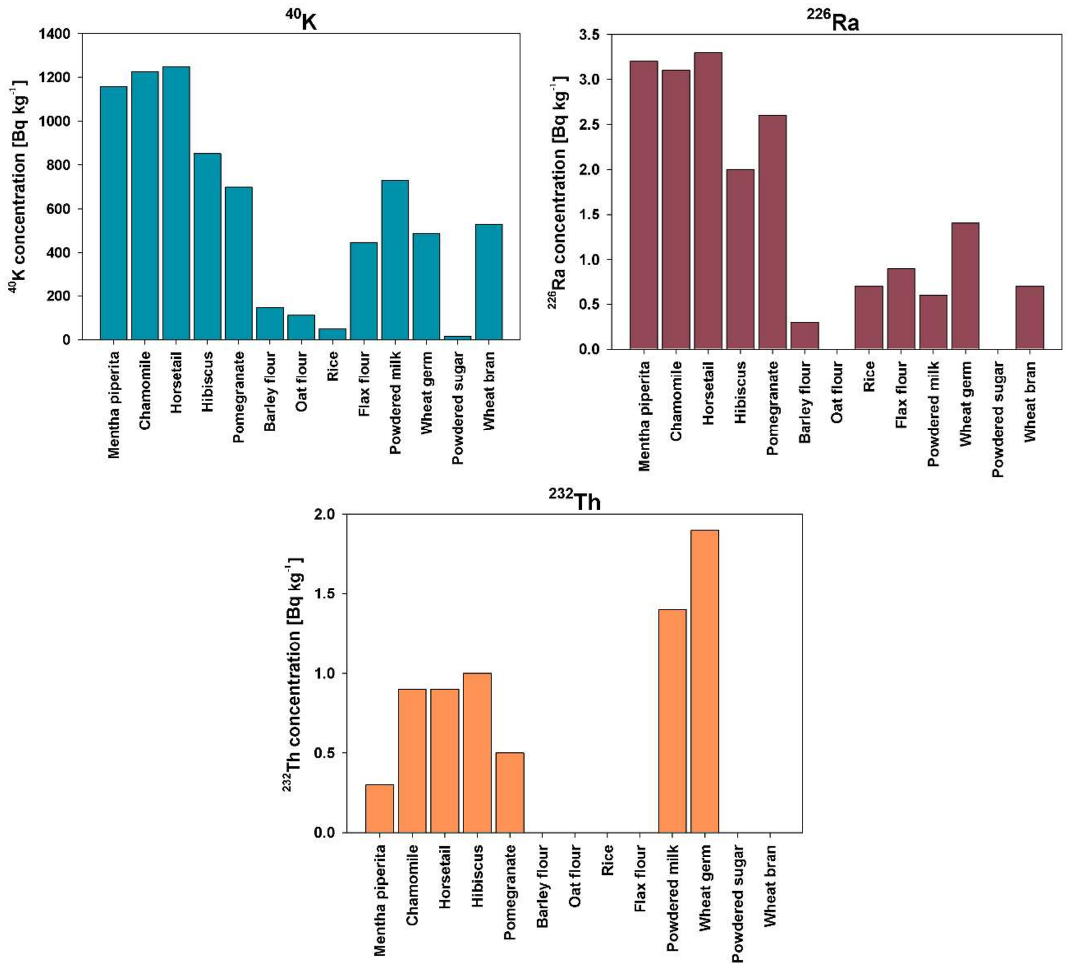

Fig. 1 Activity concentrations of natural radionuclides measured in food samples. The missing bars indicate that the radionuclide was not detected in the sample.

The dissolution of ^{137}Cs activity in tea products had been calculated as 60%. People in Serbia drink an average of two cups or 0.4 liters of tea a day [6]. The first column of Table 1 gives the recommended amounts of dried herbs for the preparation of herbal tea. In accordance with these data and equation (2), Table 1 shows the estimated activity concentrations of ^{137}Cs and natural radionuclides in herbal tea samples and the values of the annual effective dose in the whole body due to the consumption of tea for an adult. Appropriate annual doses are in the range of 2.3–8.5 nSv for ^{137}Cs, 14.1 - 21.7 nSv for ^{232}Ra, 18.4 - 73.6 nSv for ^{232}Th and for ^{40}K 10.4 - 22.9 nSv.

Table 1. Estimated activity concentrations (C) and annual doses (E_{ing}) of intake of natural radionuclides and ^{137}Cs due to the consumption of tea for an adult.

		^{137}Cs		^{226}Ra		^{232}Th		^{40}K	
Sample	Amount (g)	C (mBq/ kg)	E_{ing} (nSv/ y)	C (mBq/ kg)	E_{ing} (nSv/ y)	C (mBq/ kg)	E_{ing} (nSv/ y)	C (mBq/ kg)	E_{ing} (nSv/ y)
Mentha piperita	2.5	4.5	8.5	24	21.7	2.6	18,4	8700	21.6
Chamomile	2.5	1.5	2.8	22.5	20.4	6	49.1	9225	22.9
Horsetail	2	4.2	7.9	19.8	17.9	5.4	44.2	7500	18.6
Hibiscus	3	1.8	3.4	18	16.3	9	73.6	7650	19.0
Pomegranate	2	1.2	2.3	15.6	14.1	2.4	19.6	4200	10.4

4. Conclusions

The levels of natural and artificial radioactivity in thirteen selected commonly used foods in Serbia were examined by gamma spectrometry. As a result, the study shows that the tested samples have no noticeable specific radioactivity except for ^{40}K. Based on the presented results of measuring radioactivity in food samples used daily, it can be concluded that radionuclides can be detected in the tested samples, but in very small quantities that do not pose a problem for human use.

References

[1] M.P. Chougaonkar, K.P. Eappen, T.V. Ramachandran, P.G. Shetty, Y.S. Mayya, S. Sadasivan V. Venkat Raj, *Assessment of ambient gamma dose rate around a prospective uranium mining area of South India – A comparative study of dose by direct methods and soil radioactivity measurements* Journal of Environmental Radioactivity 71 (2003) 275–297.

[2] A. Awudu, A. Faanu, E. Darko, G. Emi-Reynolds, O. Adukpo, D. Kpeglo, F. Otoo, H. Lawluvi, R. Kpodzro, I. Ali, M. Obeng, B. Agyeman, *Preliminary studies on 226Ra, 228Ra, 228Th and 40K concentrations in foodstuffs consumed by inhabitants of Accra metropolitan area, Ghana*. Journal of Radioanalytical and Nuclear Chemistry 291 (2012) 635–641.

[3] Venter, A., Coughtrey, P. J., Carini, F. and Inoue, Y., *Radionuclide transfer to fruits: a critical review.* Journal of Environmental Radioactivity 52 (2001) 117–122.

[4] United Nations Scientific Committee on the Effects of Atomic Radiation. Sources, effects and risks of ionizing radiation, Report of UNSCEAR to the General Assembly, United Nations, New York, USA (1988).

[5] A. Jose, J. Jorge, M. Cleomacio, V. Sueldo, D.S. Romilton, *Analysis of the 40K levels in soil using gamma spectrometry,* Brazilian Archives of Biology and Technology 48 (2005) 221-228.

[6] M. Jevremovic, N. Lazarevic, S. Pavlovic, M. Orlic, Radionuclide concentrations in samples of medicinal herbs and effective dose from ingestion of 137Cs and natural radionuclides in herbal tea products from Serbian market. Isotopes in Environmental and Health Studies 47 (2011) 87-92.