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TOTAL BETA ACTIVITY, POTASSIUM-40 ACTIVITY AND RESIDUAL BETA ACTIVITY IN DIFFERENT TEA SAMPLES

Abstract

Use of nuclear energy in peaceful purposes causes contamination of the environment with radionuclides (Chernobil, 1986; Fukushima–Daiichi, 2011). Therefore, level monitoring of radionuclides in the environment in certain region is of fundamental importance, because it creates a base for providing a criteria of radiation safety of human population. In this work basic radiation data: total beta activity (TbA), potassium-40 activity ($A^{40}K$) and residual beta activity (RbA) in 8 tea samples from different shops in Novi Sad have been measured. Total beta activity ranged from 281.6 ±15.9 Bq/kg to 713.6 ±41.6 Bq/kg, and residual beta activity from 3.6–34.1 Bq/kg. Measuring of TbA and potassium-40 activity can serve as a first phase of radiation-hygienic control.

Key words: *tea, total beta activity, potassium-40 activity, residual beta activity.*

INTRODUCTION

Tests of nuclear arms, that were especially frequent in 1960's, and the use of nuclear energy for peaceful purposes, causes environmental radionuclide contamination. It is estimated that in the accident of the nuclear plant in Chernobyl (1986) about 7×10^{17} Bq of radioactive material was released in atmosphere [15]. According to the International Nuclear Event Scale the accident in Fukushima Daiichi (Japan, 2011)

was declared the highest level accident (seven), i.e. the release of radioactive material with highly dangerous consequences on humans and the environment [8]. Great nuclear accidents, as the above mentioned, lead to radicontamination of soil and water on large areas and thus jeopardize herbal production, and thereby human beings. Incorporation of radionuclides in plants occurs through leaves (foliated deposit) and root resorption as well [1]. Special importance for humans play plant species that are used to obtain phyto-preparations in the pharmaceutical industry in a form of monocomponent teas or tea mixtures, which have been widely used in traditional medicine. A as source for obtaining the raw materials used in medicine are wild plants from nature (over 200), or from plantations (there are about 30) [11]. There is a continuous need for organized and permanent radiation-hygienic control (RH) of plants used as raw material in the pharmaceutical industry.

Withing the RH-control determining the activity of biological significant radionuclides (BSR), both natural and manufactured, is of special importance. Among natural radionuclides significant is potassium-40, that is present with mass fraction of 0.0119%, and its contribution of the total beta activity in all biological community is over 90% [6]. Potassium-40 is a beta-gamma emitter with a physical half-life, $T_{1/2} = 1.28 \times 10^9$ years [2]. Among radionuclides that have been first produced are ^{137}Cs and ^{90}Sr which due to their physical and chemical characteristics, are highly toxic and contribute to the radiation load [9].

The aim of examining the tea samples from different shops in the city of Novi Sad was aimed to determine total beta activity, the activity of potassium-40 beta and residual activities, in order to gain an insight into the radiocontamination of these phyto-products knowing their wide use in therapy and a potential to accumulate biologically significant radionuclides.

MATERIAL AND METHODS

The samples were collected from tea shops in Novi Sad city during the year 2008, in their original packaging. Eight different types of tea were sampled.

Sage - (Salvia officinalis L.,Lamiaceae) is a perennial, greenish, strongly branched small bush. The stem grows up to 70 cm high. Best quality drug is known as wild Dalmatian sage or „sag". As a secondary pharmaceutical raw material dried sage leaves are used. Drugs (tea), extracts and essential oil have antimicrobial, spasmolitic and adstringent effect [11, 13].

Common Bearberry –(Arctostaphylos uva ursi L., Spreng, Ericaceae) is also known as Planika, in Serbian. It grows as an evergreen small bush, with liana branches. Medical raw material are young dried leaves pf bitter and pungent teast. The leaves are also known as „bear's grape". The leaves are used in treating urinary tract infections, at the stage when antibiotics are not needed [11].

Roselle – (*Hibiscus sabdariffa, Malvaceae*) belongs to a group of so-called vitamin drugs. Fleshy small leaves of the flower are used for making tea. It has slightly laxative effect [11].

Nettle – (*Urtica dioica L.,Urticaceae*) is a traditional drug. The tips of branches with leaves, leaves, the whole plant or only the root is used. Due to the effects of tannin [13, 14] nettle tea is used in treating diarrhea, white washing, bleeding hemorrhoids, and in general to stop internal and external bleedings. Nettle leaf is a source of vitamine K [11].

Corn silk – (*Maydis stigmata, Zea mays, Poaceae*), along with roselle and neetle, belongs to a group of vitamin drugs. It is rich in vitamin K [11]. Due to the presence of potassium salts and other ingredients it has effects of a mild diuretic. Thanks to salicilial acid, corn silk alleviate rheumatic pains [13].

St John's wort – (*Hypericum perforatum L., Hypericaceae*) is a perennial plant with branched roots. The stem is 40-50 cm high. Raw material for drugs are dried flowers in the peak of bloom. St John's wort is a popular folk medicine. Most commonly used is its oil extract. It is used for healing external wounds, burns and injuries of skin and mucous. Internally, it is applied for gastric ulcers. It is also used as an antidepressant [11].

Marshmallow – (*Althaea officinalis L., Malvaceae*) is a perennial, herbaceous plant. The root is powerful and ramified. The stem is erect and branched. The raw material are peeled and dried roots of plants not older than two years. Marshmallow root is bland, mucilaginous and odourless. The leaf of marshmallow is also used as drugs. Marshmallow alleviates the irritation to cough and relieves irritation of dry cough. It also serves to rinse the lining of the mouth, nose [11].

Chamomile – (*Matricaria chamomilla L., Asteraceae*) is an annual plant with thin spindle root. The stem is up to 60 cm high, branched in upper part. Nowadays it is reared. Chamomile blossom are used as medicine raw material (Chamomillae flos) with a flower stem 1 cm long. The smell of chamomile is specific and aromatic. Today, many phyto-preparations are formulated on the basis of this drug. They are applied externally and internally, as an antiseptic, anti-inflammatory and mild spasmolytics remedy [11].

Tea samples were mineralized at the temperature of 450 ± 10°C in a furnace. Total beta activity was determined from the mineral rest after burning dried samples [12], by the anticoincidental device for measuring low-beta activity, type OMNI GUARD, company Tracerlab (USA), and its background radiation was less than 1 imp/min. The efficiency of the measuring device is determined by the method of standard sources. As a standard source ^{40}K in KCl were used [5].

The content of potassium in the samples was determined using emission spectrophotometry on the device Spectr AA-10, Varian company, at a wavelength of 766.5 nm using cesium as a ion-suppressor. The level of potassium-40 activity in tea samples was determined on the basis of total potassium, using potassium value of the mass activity of 31.561 Bq/g K [6, 10]. Residual beta activities were determined from the difference between total beta activity and the activity levels of potassium-40.

The measured activities and potassium contents are given per kg air-dry matter. The obtained values were statistically processed. Between total beta activity and the activity of potassium-40, t-test was made.

RESULTS AND DISCUSSION

The measurement results are displayed in Table 1, where the existance of three groups of samples is visible regarding statistically significant difference between the values of TbA and $A^{40}K$. While in the sage, roselle and nettle tea there is no statistical significance, in the samples of common bearberry, St John's wort and marshmallow the level of significant difference was $p < 0.01$, and in the samples of corn silk and chamomile the level of significance was $p<0.05$. The values of total and residual beta activity ranged from 281.6 ± 15.9 Bq / kg (St John's wort) to 713.6 ± 41.6 Bq / kg (chamomile) and of 3.6 Bq / kg (sage) to 34.1 Bq / kg (marshmallow), respectively. The activity of potassium-40 ranged from 249.3 ± 14.0 Bq / kg (marshmallow) to 693.7 ± 39.5 Bq / kg (chamomile). The highest values of ^{40}K were found in the teas with highest content of potassium (roselle, nettle, corn silk, chamomile), which is directly correlated. The contribution of potassium-40 in total beta activity in all the samples was above 90%, except for marshmallow (88%), what is agreement with the data in literature [6]. The average value of potassium-40 activity in samples of tea was 486.49 ± 26.70 Bq / kg, what is in accordance with the results of other authors.

Table 1. The content of potassium-40 activity, total beta activity and residual beta activities in different types of tea samples

Tea	Content of K [g/kg]	$A^{40}K$ [Bq/kg]	TbA [Bq/kg]	RbA [Bq/kg]	Contribution ^{40}K(%)	Statistical importance
Sage	14.36 ±0.76	453.2 ±24.0	456.8 ±30.5	3.6	99.2	$p > 0.05$
Common Bearberry	10.66 ±0.60	336.4 ±18.8	362.8 ±28.5	26.4	92.7	$^{**}p < 0.01$
Roselle	21.06 ±1.10	664.7 ±34.6	674.2 ±41.9	9.5	98.6	$p > 0.05$
St Johns wort	8.42 ±0.45	265.7 ±14.1	281.6 ±15.9	15.9	94.4	$^{**}p < 0.01$
Marshmallow	7.90 ±0.44	249.3 ±14.0	283.4 ±18.1	34.1	88.0	$^{**}p < 0.01$
Corn silk	17.13 ±0.99	540.6 ±31.4	553.3 ±30.7	12.7	97.7	$^{*}p < 0.05$
Nettle	21.81 ±1.18	688.3 ±37.2	694.5 ±56.4	6.2	99.1	$p > 0.05$
Chamomile	21.98 ±1.25	693.7 ±39.5	713.6 ±41.6	19.9	97.2	$^{*}p < 0.05$

In 2002 a group of authors from the Faculty of Science, Novi Sad (Department of Physics) analyzed several types of food, including 6 samples of tea and medical herbs collected from the area of Novi Sad. The average value of ^{40}K activity in the samples of tea and medical herbs was 591 ± 110 Bq / kg. The highest value of potassium-40 activity was measured in mint tea [16].

Harb (2007) measured radioactivity of several radionuclides (^{238}U, ^{226}Ra, ^{210}Pb, ^{228}Th, ^{232}Th, ^{228}Ra, ^{137}Cs and ^{40}K) in 10 samples of tea from the Egypt market. Mass radionuclide activity was determined by direct gamma spectrometry using HPGe detector. The average value of ^{40}K in tea amounted to 623 ± 25 Bq / kg, while the lowest was 470 ± 20 Bq / kg, which is in agreement with our measurements, although different methods were applied.

Di Gregorio et al. (2004) measured the activity of ^{137}Cs and ^{40}K, using γ-spectrometry in more than 50 food samples, among which tea samples and the samples of a particular plant named yerba mate, produced as national drink of Argentina, Paraguay, Uruguay and Southern Brazil served as an alternative to coffee. In all the samples of tea and yerba mate the values for ^{40}K ranged from 200 to 875 Bq / kg, with lower values (208-412 Bq / kg) detected in the plant yerba mate. A higher values were measured in teas (from 404 to 877 Bq/kg), what is also comparable with the results of our measurements.

Based on an extensive testing of food samples in Serbia to the content of ^{40}K and the values obtained from measuring food for consumption in of 1995 (fruits, cereals, meat, fish, eggs, dairy products, vegetables and alcoholic beverages), Đujić (1995) reports that total daily intake of potassium-40 via these foods was 78.1 Bq, which at that time was only 10% lower than the world average (85 Bq). In average humans receive of about 180 μSv per year, the effective equivalent doses from potassium-40, which is consumed through food and water [15].

Because of the significant difference of the values determined between TbA and A^{40}K it is necessary to determine the content of other beta-emitters in teas, by the method of gamma spectrometry.

CONCLUSION

In five, out of eight different tea samples statistically significant difference was determined ($p < 0.05$; $p < 0.01$), between total beta activitiy and potassium-40 activity. The values of residual beta activities indicate the presence of beta-active radionuclides other than ^{40}K. These results should serve as a basis for further investigation of gamma-spectrometric and thus contribute to radiation-hygienic control of these very important phyto-products and radiation safety of overall population.

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УКУПНА БЕТА АКТИВНОСТ, АКТИВНОСТ ^{40}K И ОСТАЛА БЕТА АКТИВНОСТ У УЗОРЦИМА РАЗЛИЧИТИХ ЧАЈЕВА

Сажетак

Коришћење нуклеарне енергије у мирнодопске сврхе доводи до загађивања животне средине радиоактивним супстанцама (Чернобил, 1986; Фукушима-Даићи, 2011). Стога праћење ниво радионуклида у животној средини има фундаментални значај, јер представља основу на којој се граде критеријуми радијационе сигурности хумане популације. У раду су мерене основне радијационе величине: укупна бета активност (UbA), активност калијума-40 (A^{40}K) и остала бета активност (ObA) у узорцима 8 врста чајева, узетих из трговина са територије града Новог Сада. Укупна бета активност се кретала у интервалу од 281,1±15,9 Bq/kg до 713,6±41,6 Bq/kg а остала бета активност од 3,6-34,1 Bq/kg. Мерење UbA и активности калијум-40 може да послужи као прва фаза у радијационо-хигијенској контроли.

Кључне речи: *чај, укупна бета аткивност, активност калијума-40, остала бета активност.*