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MEASUREMENT OF THE RADIOACTIVITY OF ^{137}Cs IN MATERIALS OF PLANT ORIGIN WITH POTENTIAL RADIOACTIVE CONTAMINATION

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One of the most dangerous phenomena of the XX century was the introduction of radionuclides into the (natural) environment what, when uncontrolled, can lead to a radioactive contamination. Serious contamination may be a consequence of the release of radioactive gases during nuclear power plants disasters, tests of nuclear weapons and to smaller extent, improper storage of radioactive materials as well as radioactive fallouts from nuclear power plants. Raw materials used in different industry branches that were acquired/collected from contaminated areas pose a risk to human health. One example of such materials are plants used in medicinal preparations. They are mainly contaminated with ^{137}Cs. The half-life of this radionuclide is long enough to allow it to be deposited in plants and soil for a very long time. Nuclear tests in the atmosphere contributed to the wide spread of fission and activation products of this isotope. It was estimated that the activity of about 9.6×10^{17} Bq ^{137}Cs was introduced this way to the atmosphere, since 76% was deposited in the northen hemisphere and 24% in the southern (1). Another important source of ^{137}Cs contamination are nuclear power plants accidents. Chernobyl disaster released the greatest amount of ^{137}Cs (activity around 7×10^{16} Bq) (2.) Even though it has been 28 years ago, because of the close geographic vicinity, ^{137}Cs contamination can be still observed in Poland. Figure 1 shows the average deposition of the ^{137}Cs concentration in soil in particular provinces of Poland in 2010 (3). These measurement results indicate that the concentration of ^{137}Cs radioisotope in particular samples taken from 10 cm thick soil layer oscillated from 0.22 to 23.78 kBq/m^2. The highest levels – registered in the South of Poland – are caused by intensive local rainfall which occurred in those territories at the time of Chernobyl accident. The highest soil average concentration of the ^{137}Cs ranging from 3 to 6 kBq/m^2 was found in Opole, Silesian and Lower Silesian voivodeships.

The ^{137}Cs undergoes radioactive decay with the emission of β particles with a mean energy of 0.52 MeV and γ rays of energy 661.7 keV. Its presence in soil has substantial effect on the contamination of human food chain. Cesium gets to the plants through the passive deposition on the aerial parts of plants as well as *via* roots. The latter way of ^{137}Cs uptake has long-term effects.

Many plant and food products may be contaminated with ^{137}Cs. According to Polish Informacyjna Agencja Radiowa (Information broadcasting agency), Belorussian Sanitary Inspection found that some types of wines are produced using radioactively contaminated fruits. Higher than allowed radioactive concentrations were also detected in many other food products. Areas heavily affected by Chernobyl accident (including Poland) still suffer from the consequences of this nuclear plant disaster. It can be suspected that companies trading with groundcover products and wanting to reduce costs, may be looking for lower quality products from unknown

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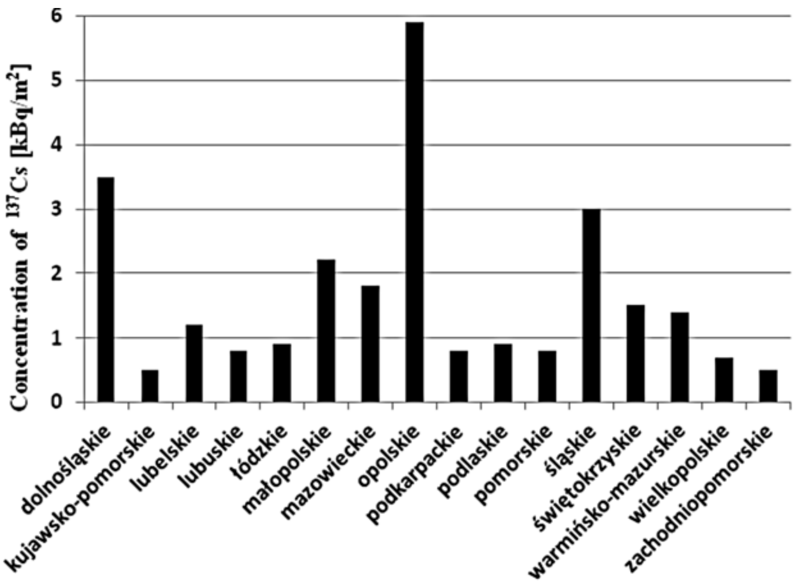

Figure 1. Average surface concentration of ^{137}Cs (10 cm-thick soil layer) in 2010 in particular provinces of Poland

Table 1. Plant-based raw materials used in the study along with the site of collection.

Plant-based raw material	Site of collection
Vaccinium vitis-idaea fruits *Vaccinium myrtillus* fruits	1. Solska Wilderness (Hamernia vicinity, near Józefów) 2. Kuźnica Ligocka – Bory Niemodlińskie 3. Bory Dolnośląskie 4. Suche Rzeki – Bieszczady
Vaccinium oxycoccus fruits	1. Solska Wilderness (Hamernia vicinity, near Józefów) 2. Przemyśl vicinity 3. Gmina Lutowiska – Bieszczady 4. Lasy Stobrawsko-Turawskie

Table 2. Dietary supplements used in the study.

Main component	Supplement brand name
Vaccinium vitis-idaea fruits	1.Biotta 2. Dried lingonberry – Biofit
Vaccinium myrtillus fruits	1. Lutein plus 2. Solgar bilberry 3. Pryzmin
Vaccinium oxycoccus fruits	1.Urinal 2. Urinatin Megafryt 3. Dried swamp cranberry – Biofit 4. Colfarm swamp cranberry 5. Solgar swamp cranberry 6. Żurawinea Max

sources. Sanitary Inspection in Belarus and Ukraine came across radioactive frozen raspberries and currants. Contaminated products very often came to European Union countries, where limits are lower than those in Belarus. Regarding the total cesium radionuclides concentration in foodstuff, the European Union limit stands at 600 Bq/kg. The importance of this issue is evidenced by the fact that one of the European Parliament debates, taking place in Strasburg (14 February 2011), entitled „Radioactive contamination of foodstuff“, was devoted to the subject of this article (4).

EXPERIMENTAL

Tables 1 and 2 show herbal medicines and dietary suplements, respectively, that were used in this study.

Radioactivity of ^{137}Cs was measured using γ-ray spectroscopy, which enables to quantify radioactivity ranging from 0.5 to 4000 Bq/kg or Bq/l in food and environmental samples such as soil, grass and ground water. Canberra γ-ray spectroscopy system coupled with three semi-conductor HPGe detectors and Genie 2000 software were used. The γ-ray spectrometric method for determining ^{137}Cs is based on the measurement of the intensity of γ radiation at 661.6 keV in both, sample and standard. Multi-γ

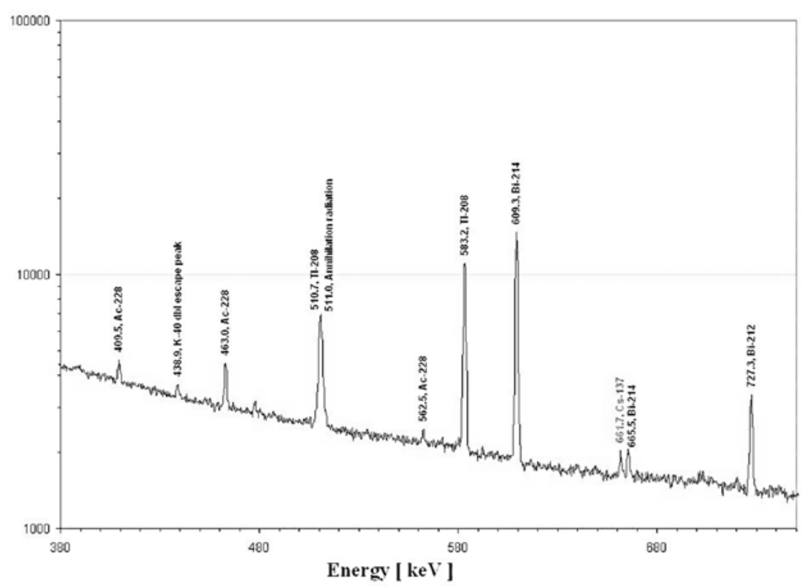

Figure 2. γ-Ray spectrum of background. Time of measurement – 60 h

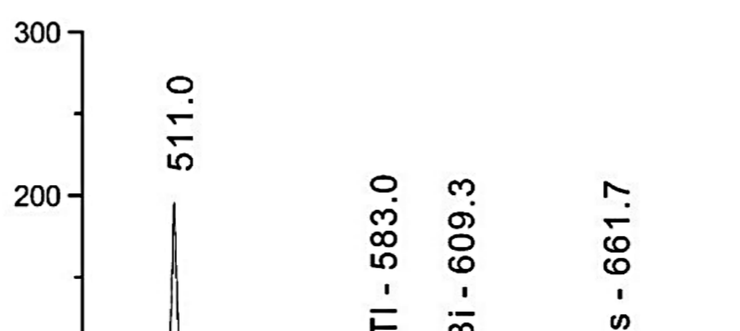

Figure 3. γ-Ray spectrum for dietary supplement Urinal. Time of measurement – 24 h

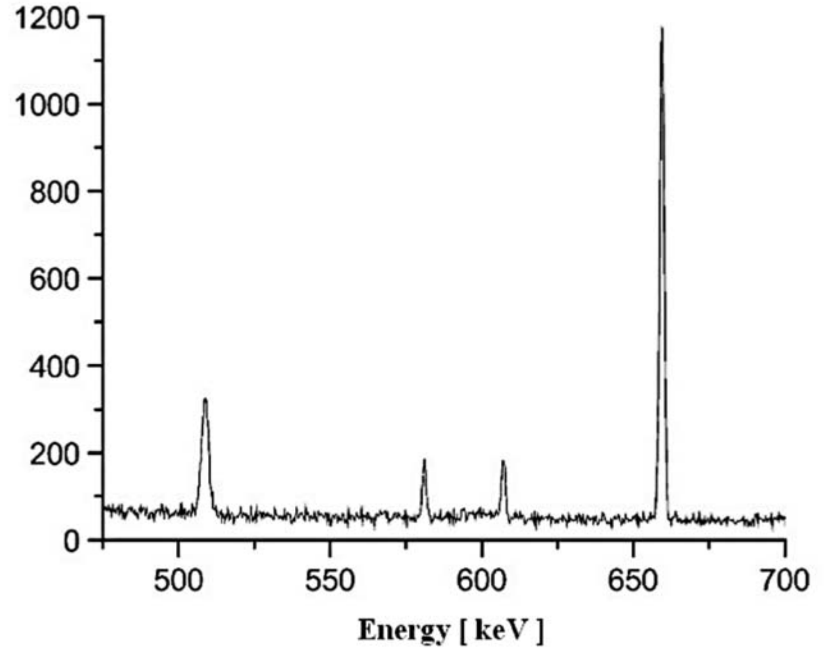

Figure 4. γ-Ray spectrum of *Vaccinium vitis-idaea* L. fruits collected in Bory Niemodlińskie. Time of measurement – 24 h

Table 3. Concentration of ^{137}Cs in plant-based raw materials with the site of collection.

Plant-based raw material Site of collection	Total activity of ^{137}Cs [Bq/kg]
Vaccinium vitis-idaea fruits	
1.Solska Wilderness (Hamernia vicinity, near Józefów)	5 ± 1*
2. Kuźnica Ligocka – Bory Niemodlińskie	30 ± 5
3. Bory Dolnośląskie	25 ± 4
4. Suche Rzeki – Bieszczady	3 ± 1
Vaccinium myrtillus fruits	
1. Solska Wilderness (Hamernia vicinity, near Józefów)	4 ± 1
2. Kuźnica Ligocka – Bory Niemodlińskie	27 ± 4
3. Bory Dolnośląskie	20 ± 4
4. Suche Rzeki – Bieszczady	1.0 ± 0.2
Vaccinium oxycoccus fruits	
1. Solska Wilderness (Hamernia vicinity, near Józefów)	4 ± 1
2. Przemyśl vicinity	8 ± 2
3. Gmina Lutowiska – Bieszczady	6 ± 1
4. Lasy Stobrawsko-Turawskie	9 ± 2

* – Expanded uncertainty; Coverage factor k = 3

mixtures in Marinelli beakers with 100 and 450 mL acitive volumes and 1.0, 1.14 and 1,15 g/cm^3 active densities were used covering the γ energy range from 88 to 1836 keV.

The 100 or 450 mL Marinelli beakers were weighted and filled with samples. If the sample volume was lower than the active volume of the beaker, distilled water was added in case of liquid samples.

In case of solid and semi-solid samples, non-reactive and easily mixible material (such as talk) was added.

The energy dependence on the detection efficiency was determined with reference standard and used to calculate the concentration of radionuclides in the samples..

RESULTS

Figure 2 shows the level of background γ radiation measured using Canberra spectrometric system. It was used as an analytical blank. The 661.6 keV line corresponding to ^{137}Cs had intensity of 3×10^{-4} cps. This value was taken into account in determination of ^{137}Cs radioactivity in all samples and standards. Other lines present in the spectra are of natural origin and had no influence on the results. Figure 3 shows the γ-ray spectrum obtained for dietary supplement Urinal. ^{137}Cs activity was below the detection limit.

Figure 4 shows the γ-ray spectrum of *Vaccinium vitis-idaea* L. fruits collected in Bory Niemodlińskie. Elevated radioactivity of ^{137}Cs (around 30 Bq/kg) is clearly visible.

The ^{137}Cs radioactivity was below the detection limit in all dietary supplements tested. Table 3 shows the activity of ^{137}Cs found in other raw materials tested.

CONCLUSIONS

None of the dietary supplements analyzed contained radioactive ^{137}Cs isotope, what indicates proper collection of raw plant materials or low concentration of these raw materials in analyzed samples.
Concentrations of radioactive cesium found in *Vaccinium vitis-idaea* L. and *Vaccinium myrtillus* are variable and depend on the site of raw material collection. They are 8 times greater for materials collected in southern voivodeships (Opole and Lower Silesian) than for those acquired in Bieszczady, what correlates with the soil contamination of these regions.

Much lower activity was found in case of *Vaccinum oxycoccos* samples (4–9 Bq/kg). There were no differences for samples collected at different areas.

The activity levels measured (maximum 30 Bq/kg) lead to negligibly low effective doses (around 0.03 mSv) even after single consumption of 1 kg. Such equivalent doses correspond to the single chest x-ray and can be considered as hormetic dose.

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Erratum

In the paper: “Influence of spray drying manufacturing parameters on quality of losartan potassium microspheres.” Acta Pol. Pharm. Drug Res., Vol. 71, No. 5, pp. 833–841 (2014), the correct authorship should read:
Andrzej Jankowski, Radosław Balwierz, Dominik Marciniak, Dariusz Łukowiec, Janusz Pluta

In Acta Pol. Pharm. Drug Res. Vol. 71, issue 5 (2014), in Table 3, p. 805, in the last column and line 9 the letters "FTMFTM" should be removed.