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# ДЕЯКІ АСПЕКТИ НАДХОДЖЕННЯ ЦЕЗІЮ-137 ДО "БАЗАРНОГО КОШИКА" У м. КИЄВІ

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# SOME ASPECTS OF CESIUM-137 ENTRY INTO "MARKET BASKET" IN KYIV CITY

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**Keywords: $^{137}$Cs, wild mushrooms and berries, "market basket", Chornobyl.**

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***Мета**. Вивчити особливості надходження дикорослих грибів та ягід на ринки, проаналізувати та оцінити концентрацію $^{137}$Cs у диких грибах та ягодах, які продавалися на кількох ринках м. Києва.*

***Матеріали та методи.** Ми відібрали набори дикорослих грибів: лисичка (Cantharellus cibarius), білий гриб (Boletus edulis), польський (Xerocomus badius), підосиновики (Leccinum aurantiacum), опеньки (Armillaria mellea), піддубники (Lactarius deliciosus), маслюки (Suillus luteus), ягоди: чорниця (Vaccinium myrtillus), журавлина (Vaccinium oxycoccos), брусниця (Vaccinium vitis-idaea) і голубика (Vaccinium uliginosum), які продавали на 5 ринках м. Києва протягом літа-осені 2018 року. Концентрацію $^{137}$Cs оцінювали за допомогою гамма-спектроскопічного методу, усереднення проводили за типами продуктів та ринками. Було проведено опитування серед продавців про збір та доставку лісової продукції на ринки.*

***Результати**. У ході роботи на 5 ринках Києва було відібрано 153 зразки – 87 грибів та 66 ягід. Визначали концентрацію $^{137}$Cs у продуктах та її відповідність санітарним нормам. Було виявлено, що санітарні норми за вмістом $^{137}$Cs перевищено у 14,8% з 54 зразків чорниці і 25% з 80 зразків грибів, зокрема 46,2% з 26 зразків лисичок та 54,5% – з 11 польських грибів. Найбільш забруднені лісові продукти продавали поблизу станції метро "Лісова". Встановлено, що забруднення лісових продуктів $^{137}$Cs залежало від місць збору та пріоритетних шляхів доставки продукції на ринок.*

***Ключові слова: $^{137}$Cs, дикорослі гриби та ягоди, "базарний кошик", Чорнобиль.***





With wild mushrooms and berries can make a significant contribution to the irradiation of the population after Chornobyl disaster due to their possible contamination by radionuclides [1, 2]. Our recent studies have shown that the consumption of mushrooms and berries at the places of their gathering gives the pronounced differences in the concentration of $^{137}$Cs in human body, both in local cohort and within one family [3]. Now we concern with the influence of forest products on "market basket" of big city. Wild berries, like blueberries and cranberries, and different species of mushrooms one can gather himself or buy at the market. In the ripening season, they can be a significant part of the diet, especially in gourmets. Wild growing foodstuff can be presented in the diet even in winter (dried and canned), harvested in autumn or bought at the market place.

**Methods.** We focused attention on several markets in the city of Kyiv near underground stations "Darnytsia", "Livoberezhna", "Lisova", "Lukianivska" where purchases were made on weekdays as well as at a regular Sunday fair in Holosievo district. The volume of the work and the cost of the products were limited by the number of samples that was taken in the work at the same time. When sampling, we took into account the accompanying information: the volume of sales, the site of gathering of the products (as the vendors called it) etc.

All sampling was carried out by the same person (the same hands), which made it possible to accumulate information about the sellers and the relevant places of gathering of the products. The products were of individual or collective gathering as well as of individual, small, and large wholesale deliveries. Sale of the products took place at the individual working places of the market. The weight of the individual fresh samples were 250-500 grams, the weight of the dry samples were about 100 grams.

Characteristically, not all visits to the market were successful. It depended on weather conditions for the growth of mushrooms and berries, favourable transportation conditions. Sometimes, the purchases were made at one market, sometimes at the other, sometimes on several ones. Some sellers worked on the permanent seats throughout the season, some of them we met again, sometimes, we didn't ever meet some of them. This was

especially true in case of the individual gathering and sale of berries or mushrooms with the same hands. In the vast majority the gathering and sale of the berries looked more organized.

We studied several spices of mushrooms, including: chanterelle mushroom *(Cantharellus cibarius)*, king bolete *(Boletus edulis),* Bay bolete *(Xerocomus badius),* aspen mushroom *(Leccinum aurantiacum),* honey agaric *(Armillaria mellea),* orange agaric *(Lactarius deliciosus)*, slippery jack *(Suillus luteus),* and berries: european blueberry *(Vaccinium myrtillus),* cranberry *(Vaccinium oxycoccos),* lingonberry *(Vaccinium vitis-idaea)* and bog bilberry *(Vaccinium uliginosum).*

*Table*

**$^{137}$Cs (Bq/kg) in mushrooms and berries, and excess above sanitary standard of 500 Bq/kg [6]**

| Product | | N | Average | SD | Median | Min | Max | Excess, N | % |
|---|---|---|---|---|---|---|---|---|---|
| **Markets** | | | | | | | | | |
| Mushrooms | Lisova | 26 | 432 | 696 | 240 | 0.3 | 3411 | 9 | 34.6 |
| | Livoberezhna | 17 | 684 | 1272 | 101 | 7.5 | 5196 | 7 | 41.2 |
| | Darnytsia | 14 | 480 | 895 | 109 | 10.3 | 3278 | 3 | 21.4 |
| | Lukianivska | 12 | 34.5 | 53.3 | 4.3 | 0.5 | 153 | | |
| | Holosievo | 1 | 5.4 | | | | | | |
| | All | 70 | | | | | | 20 | 28.2 |
| Blueberry | Holosievo | 19 | 69 | 137 | 24.5 | 8.5 | 609 | 1 | 5.3 |
| | Darnytsia | 13 | 162 | 303 | 31 | 6.3 | 1110 | 1 | 7.7 |
| | Lisova | 13 | 766 | 965 | 183 | 20.9 | 2680 | 6 | 46.2 |
| | Livoberezhna | 6 | 95 | 90 | 85 | 8.4 | 260 | | |
| | Lukianivska | 2 | 192 | 127 | 192 | 102 | 281 | | |
| | All | 52 | | | | | | 8 | 15.4 |
| Cranberries | Holosievo | 4 | 127 | 110 | 114 | 13 | 265 | | |
| | Darnytsia | 3 | 121 | 67 | 122 | 54 | 187 | | |
| | Lisova | 1 | 80 | | | | | | |
| | Lukianivska | 1 | 40 | | | | | | |
| Bog bilberry | Livoberezhna | 1 | 170 | | | | | | |
| Ling onberry | Darnytsia | 1 | 130 | | | 33.9 | | | |
| | Livoberezhna | 1 | 122 | | | 19.6 | | | |
| **Kind of product** | | | | | | | | | |
| Mushrooms | Chanterelles | 26 | 726 | 1172 | 331 | 3.1 | 5196 | 12 | 46.2 |
| | King bolete | 21 | 146 | 194 | 51 | 3.9 | 762 | 1 | 4.8 |
| | Bay bolete | 11 | 772 | 946 | 546 | 16 | 3411 | 6 | 54.5 |
| | Aspen mushroom | 10 | 147 | 246 | 55 | 2.2 | 808 | 1 | 10.0 |
| | Honey agaric | 7 | 0.7 | 0.33 | 0.69 | 0.3 | 1.3 | | |
| | Orange agaric | 5 | 49 | 37 | 47 | 1.2 | 88.5 | | |
| | Slippery jack | 3 | 217 | 306 | 76 | 8 | 568 | 1 | 33.3 |
| | All | 83 | | | | | | 21 | 25.3 |
| Blueberry Д | | 54 | 257 | 563 | 53 | 0.8 | 2680 | 8 | 14.8 |
| Cranberries | | 9 | 117 | 84 | 101 | 13.2 | 265 | | |
| **Routes** | | | | | | | | | |
| Mushrooms | Narodychi - | 10 | 99 | 126 | 34 | 2.2 | 342 | | |
| Blueberry | Zhytomyr | 2 | 8.6 | 11.0 | | 0.8 | 16.3 | | |
| Mushrooms | Ivankiv- Kyiv | 2 | 686 | 198 | | 546 | 826 | 2 | 100 |
| Mushrooms | Chornobyl — Kyiv | 2 | 2128 | 1846 | | 823 | 3433 | 2 | 100 |
| **Krakow market** | | | | | | | | | |
| Mushrooms | Boletus edulis | 7 | 34.6 | 9.5 | 56.6 | 8.6 | 160 | | |
| | Xerocomus badius | 4 | 173.9 | 75.4 | 205.6 | 62.9 | 482 | | |

Direct gamma spectrometric measurements for the investigation of the concentrations of $^{137}$Cs and $^{40}$K were conducted with the help of semiconductor gamma spectroscopic system produced by ORTEC Inc., based on multichannel buffer model 919 and detectors, model GEM-40220 and GEM-50250, each was set into the iron shield of 20 cm thick. Time of Spectra acquisition set ranged from two to several hours. We used a source Amersham CO-570 and the derivatives to calibrate the gamma spectroscopy system. To check and ensure the quality of measurement system, the Laboratory has taken part in the IAEA comparative tests since 1990 [4]. One sample of a recent comparison was used for cross-check measurements [5].

**Results.** Gathering and sale of the forest foodstuff were various: individual gathering and sale (with the same hands), organized gathering and sale with a division of labour, retail sale from the wholesale markets. A course of the accumulation of samples, mushrooms, in particular, was modified by weather conditions, that is, mushrooms could be taken from the sites with the favourable conditions for their growth, gathering, transportation. According to the information of the sellers, the investigated mushrooms and berries were gathered mainly in the northern regions of Ukraine: Chernihiv, Kyiv, Zhytomyr, Volyn, Khmelnytskyi, and, in addition, in Vinnytsia and Zakarpattia regions. At the individual gathering and sale, individual preferences and convenient public transport routes were observed, for example: Nizhyn (Chernihiv Region) and Khmelnytskyi Region > Central Train Station > Lukianivska Underground Station; Zhytomyr and Volyn > Central railway sta-

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***Objective**. We studied the peculiarities of the entry of wild mushrooms and berries to the markets, analyzed, and evaluated the concentration of $^{137}$Cs in wild mushrooms and berries which were sold in several markets of Kyiv city.*

***Materials and methods.** We sampled the sets of wild mushrooms: chanterelle (Cantharellus cibarius), king bolete (Boletus edulis), bay bolete (Xerocomus badius), aspen mushroom (Leccinum aurantiacum), honey agaric (Armillaria mellea), orange agaric (Lactarius deliciosus), slippery jack (Suillus luteus), and berries: european blueberry (Vaccinium myrtillus), cranberry (Vaccinium oxycoccos), lingonberry (Vaccinium vitis-idaea) and bog bilberry (Vaccinium uliginosum) that were sold at 5 markets of Kyiv in summer-autumn period of 2018. The concentration of $^{137}$Cs in the samples was estimated with the help of gamma-spectroscopic method, averaging was performed by the types of the products and by the markets. A survey on the collection and delivery of forest products to the markets was carried out among the sellers.*

***Results**. 153 samples, including 87 mushrooms and 66 berries, were taken at 5 markets of Kyiv. $^{137}$Cs concentrations in the products and their conformity to the sanitary standards were determined. Sanitary standard of $^{137}$Cs content was exceeded in 14.8% of 54 blueberries samples and in 25% of 80 mushroom samples, in particular, in 46.2% of 26 samples of chanterelles and in 54.5% of 11 samples of bay bolete (Xerocomus badius) mushrooms. The most contaminated forest products were sold near "Lisova" underground station. $^{137}$Cs contamination of the products depended on the place of gathering and the prior routes of product's delivery.*

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tion > subway > left bank of the Dnipro river, underground stations "Livoberezhna", "Darnytsia", "Lisova". Accumulation of the forest products (berries) in the hands of the distributors, who get them from different places for subsequent retail sale showed that often the information about origin of the products was distorted or masked (or substituted), taking into account the content of radionuclides for the convenience of its sale, because the majority of buyers ask first about the origin of the product, and then about its cost.

During our sample selection (purchases), the repeated contacts with the sellers took place. The reaction of the sellers to the repeated contact was individual and extremely diverse: they recognized us, didn't recognize (or pretended), were even interested in the purpose of the purchase, and so on. The vendors were mostly open to communication, especially when purchase had been already completed.

Averaged findings on the content of radionuclides are given in the table (mushrooms and berries by the markets and by species). Findings on the excess of sanitary standards are presented only significant (>0). The table (at routes section) shows the results of the investigations of the samples collected on the routes where the products were bought at the unorganized sale sites near the roads, there is no statistical selection, but it is shown as a possible study variant of the entry to the food basket.

By the results of our investigations, the highest $^{137}$Cs contamination of the forest products is observed at the market near the underground station "Lisova" (excess of $^{137}$Cs concentration sanitary standard for mushrooms is in 34.6% of the samples, blueberries – in 46.2%), then the markets "Livoberezhna", mushrooms – 41.2%, "Darnytsia", mushrooms – 21.4%. As it is demonstrated in the table, other berries (bog blueberries and lingonberries) were rare at the market, only 3 samples and without excess of the standard. Later, when the cranberries were matured, there was no excess of $^{137}$Cs norm, which could testify about their organized gathering in the sites that gave a relatively clean product and/or about a need in the study of a larger sample set.

The table shows that $^{137}$Cs concentration in almost half chanterelles (46.2% of 26 samples) exceeds sanitary standard, 54.5% – of Xerocomus badius mushrooms, 10% – aspen mushroom, 4.8% – king bolete and 25% of all examined mushroom species (we didn't take into account the samples of two routes: Ivankiv and Chornobyl). The sample set of 7 honey agaric shows an extremely low $^{137}$Cs content, which first may be due to the different but cleaner sites of the gathering of mushrooms. 8 samples of the European blueberries demonstrated an excess of sanitary standard (14.8% of 54 samples).

Evaluating a contribution into "market basket", we collected some samples and compared the available information on some kinds of mushrooms in Krakow "market basket" (at the end of table). The dry mass of the samples makes up from 26 g to 45.5 g, assuming 10x factor for dry ones (with 7% uncertainty), however, it can be a bit more. According to this data set, only one sample is close to sanitary standard and doesn't exceed it.

According to our study, $^{40}$K concentration made up (140±56) Bq/kg in 85 mushroom samples, (45±14) Bq/kg in 55 European blueberry samples, (29±6) Bq/kg in 8 cranberry samples. $^{40}$K concentration in different species of mushrooms made up (190±61) Bq/kg in 26 samples of chanterelles, (106±33) Bq/kg in 20 samples of king bolete, (126±25) Bq/kg in 12 samples Bay bolete, (118±30) Bq/kg in 10 samples of aspen mushroom, (166±32) Bq/kg in 7 samples of honey agaric, (123±60) Bq/kg in 4 samples of Orange agaric, (96±25) Bq/kg in 3 samples of slippery jack that can be explained with the peculiarities of their structure – soft and/or hard.

**Conclusions**

According to the results of the study, the concentration of $^{137}$Cs exceeds the current sanitary

standard in 25.3% of 83 samples of wild mushrooms at the markets. The percentage of excess depends on the Kyiv's markets: “Livoberezhna” – 41.2% of 17 samples and “Lisova” – 34.6% of 26 samples and the type of mushrooms: bay bolete (Xerocomus badius) – 54.2% of 10 samples and chanterelles – 46.2% of 26 samples.

❑ The excess of the current sanitary standard of $^{137}$Cs concentration in the European blueberries, sold at the markets, were identified in 14.8% of 54 samples, and in 46.2% of 13 samples from the market place near the underground station “Lisova”.

❑ There was no excess of $^{137}$Cs current sanitary standards in cranberries (9), bog bilberry (1), lingonberry (2).

❑ Some results obtained from a small set of samples require a confirmation, which concerns, first of all, the study of certain types of mushrooms and berries and their correspondence to the sites of their gathering.

❑ We surveyed the situation only for some markets in Kyiv. We mentioned some other ways to be studied by which the wild berries and mushrooms fall in the food basket. High $^{137}$Cs concentrations may be presented at Krakiw market far from Chornobyl. Information from the vendors about the origin (sites of gathering) of mushrooms and berries is sometimes distorted, replaced, disguised because of the expected levels of radioactive contamination of the products.

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