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Radionuclide Activity Concentrations in Some Wild Fungi and Nourished Mushrooms and Their Composts

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ABSTRACT

In this study, natural and artificial radioactivity concentrations in *Agaricus bispora* (nourished mushroom) and their composts, *Cantharellus cibarius* and *Coprinus micaceuc* (wild species) were determined. Samples were collected from Sahne and two kinds of wild mushroom species from Songhor Koliai township gardens all located in Kermanshah Province were collected. HPGe gamma ray spectrometry system was used to determine the specific activities of ^{238}U, ^{235}U, ^{232}Th, ^{40}K and ^{137}Cs. The radioactivity concentrations of ^{238}U, ^{235}U and ^{232}Th in the edible mushroom samples in different cultivation were lower than MDA (Minimum Detectable Activity), and for ^{40}K and ^{137}Cs they were equal to 1895.24±14.21–1920.24±14.71 Bq/kg and up to 0.72±0.06 Bq/kg respectively. Our results of specific activities of ^{238}U, ^{235}U ,^{232}Th, ^{40}K and ^{137}Cs in the composts were equal to 3.40±0.81, up to 5.24±0.34, 6.59±1.63-7.82±1.37, 1166.12±33.21–1428.27±13.71 and 0.75±0.24–1.97±0.27 Bq/kg respectively. The edible mushroom in different cultivations shows that the radioactivity concentrations are close to or lower than MDA. The radioactivity concentrations in the composts indicate the low pollution of these regions by nuclear accident or nuclear weapon test. The consumption of the mushrooms would impose no health consequences to the consumers.

1 INTRODUCTION

Natural and artificial radioactivities are the main radiation sources of human's exposition. Uranium (^{238}U and ^{235}U), Thorium (^{232}Th) and Potassium (^{40}K) are the main elements contributing to natural terrestrial radioactivity (UNSCEAR, 1993). The average ^{238}U content in the Earth`s crust has been estimated to be 2.7 mg/kg and its concentration may be as high as 120 mg/kg in phosphate rocks (Padam et al., 1996). Meanwhile, the ^{232}Th average contents of the Earth's crust is about 9.6 mg/kg (Firestone *et al.*, 1996). Environmental pollutions by radioactive isotopes result from nuclear weapon tests and accidents in nuclear power plants (Kalač, 2001; Dupre et al., 2008). Release of radioactive materials from different nuclear industries also causes the increase of

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radioactivity levels in the environment. The increase in environmental radioactivity has contributed to the increased radiation dose of general population. The situation changed dramatically after the Chernobyl nuclear accident in 1986. The management of contaminated areas is crucial. Radiocesium pollution constitutes, indeed, a serious hazard for human health as these radioactive elements may be transferred through the food chain (Dupre et al., 2008). After the Chernobyl accident, mushrooms absorbed considerable amounts of radioactive elements (Tsvetnova and Shcheglov, 1994). High radioactivity levels of some wild-growing mushroom species (e.g. higher fungi, macrofungi) were observed (Kalač, 2001). Kalač (2001) showed that different species of mushrooms accumulate different radiocesium amounts (Heinrich, 1993; Kalač 2001). In European countries, intensive researches have focused to verify the artificial radionuclide contamination levels caused by the Chernobyl accident. The environmental bio-monitoring has demonstrated that diverse organisms such as crustaceans, fishes and mushrooms are useful to evaluate the contamination and quality of the ecosystems. Tsvetnova and Shcheglov (1994) showed that radionuclide accumulation in mushroom depends on its ecology, e.g. mycorrhiza-forming (symbiosis), saprophytism, xilophytism, soil pollution and moisture. Tadaaki et al. (2004) showed that the ^{137}Cs content in mushroom depends on cultivation methods. For example, the ^{137}Cs activity concentration in cultivated mushrooms on sawdust-rice bran medium bed was lower than those cultivated on logs bed (natural woods with bark). Experimental studies have also shown that mushrooms have a significant nutritional as well as medicinal value, acting as antitumor, antiviral and reducing cholesterol agents (Pavanelli de Castro, 2011). After nuclear accidents, the fungi species are important tools for determination of radioactive pollution. The aim of this study is to determine radionuclide activity concentrations in nourished mushrooms (*Agaricus bispora*), two types of wild fungi species (*Cantharellus cibarius* and *Coprinus micaceuc*) and their composts in two regions of Iran. In this work, radioactivity concentration was determined using gamma ray spectrometry method including high resolution HPGe detector system.

2 MATERIALS AND METHODS

2.1 Fungi and composts sampling

Nourished mushroom samples were collected from Sahne, and two kinds of wild mushroom species from Songhor Koliai township gardens. Using random integration and experimental sampling, a combined operation was undertaken to collect the samples in this study. Samples of edible mushroom were taken at various stages with an average weight of 10 kg fresh mushroom from Gharch Baran Company. The samples were washed in distilled water two times for 10 minutes to remove the soil and other unwanted material. Then, they were chopped by plastic knife into small pieces and spread in place with special take care for preliminary drying. It took two hours for drying mushroom in an oven with 200 ^{o} C temperature. Next, they got mild and were packed in Marinelli Beaker standard container with the net weight of 330 g. The compost samples were randomly collected from media beds before and after the first mushroom cultivation and also after the second cultivation.

2.2 Fungi identification

After transferring all the cultivated and wild mushrooms to the systematic plant laboratory in Arak, morphological characters

such as cap, stipe, gills shape and position were measured. Their spores were studied using blue lacto phenol and light microscopy methods. Then, fungi were identified using the available data and keys (Svrček, 1977). Fig. 1 shows the morphological characters of the present mushrooms and their scientific labels.

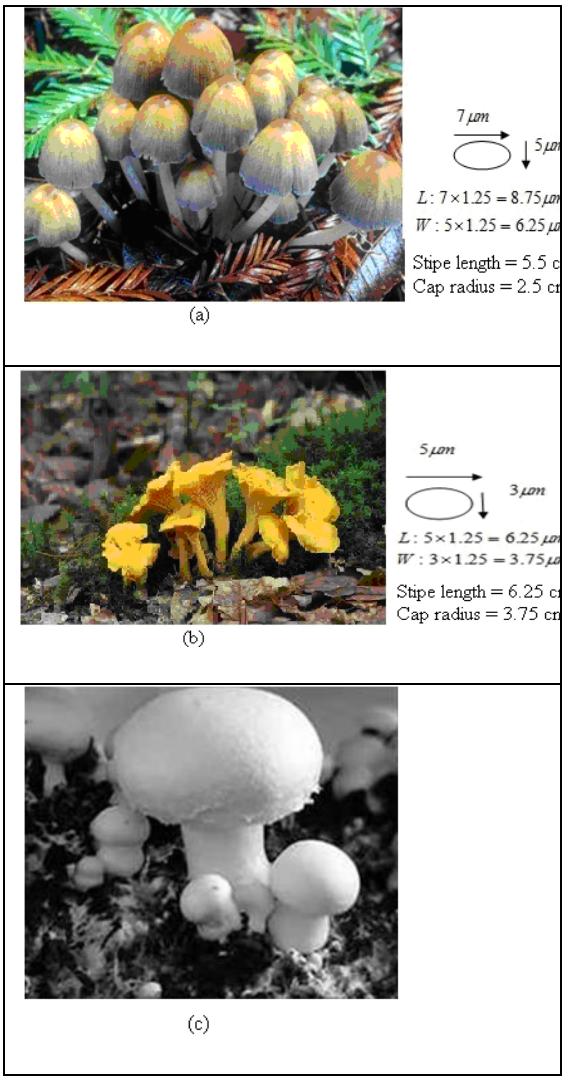

Fig. 1. Mushrooms under consideration.
(a) *Coprinus micaceuc* (wild mushroom),
(b) *Cantharellus cibarius* (wild mushroom), and
(c) *Agaricus bispora* (cultivated mushroom).

2.3 Sample preparation

All the composts and cut mushrooms were air dried separately. Then, oven was dried in 200°C for 2 hours. All the samples were powdered after passing by mesh no. 50. They were kept in standard Marinelli beakers for minimum 340 days.

2.4 Radionuclide activity determination

Gamma spectrometry was done using a HPGe detector with a relative efficiency of 30% and full width at half maximum (FWHM) of 1.95keV for ^{60}Co gamma-energy line at 1332.520 keV. The detector was shielded in a chamber of two layers 10 cm thick lead and 2mm thick by copper to reduce the background radiation. The obtained spectra were analyzed using computer software MEASTRO with multichannel analyzer (8192 channels). Spectrum analysis was carried out using GAMMAVISION software. Background radiation was measured in the same condition with empty Marinelli container and reduced of all spectra. Standard plant sample sources, which contain ^{137}Cs, ^{152}Eu, and ^{241}Am with specified activities, were used for calculation of the absolute efficiency. The detector efficiency calibration was obtained based on the IAEA 154 instruction (International Atomic Energy Agency (http:// www .environmental -studies. de). The counting geometry of samples, standard mixed source for the efficiency calibration and the background measurement were kept constant. The counting time of all spectra was 86400 s. The calibration curve with polynomial method fitted the curve chosen from the software program (see Fig. 2) and the consequent nuclear activities were determined. The gamma spectra were recorded by LRSM BSI program, as shown in Fig. 3. The radionuclide activities were determined using Eq. (1).

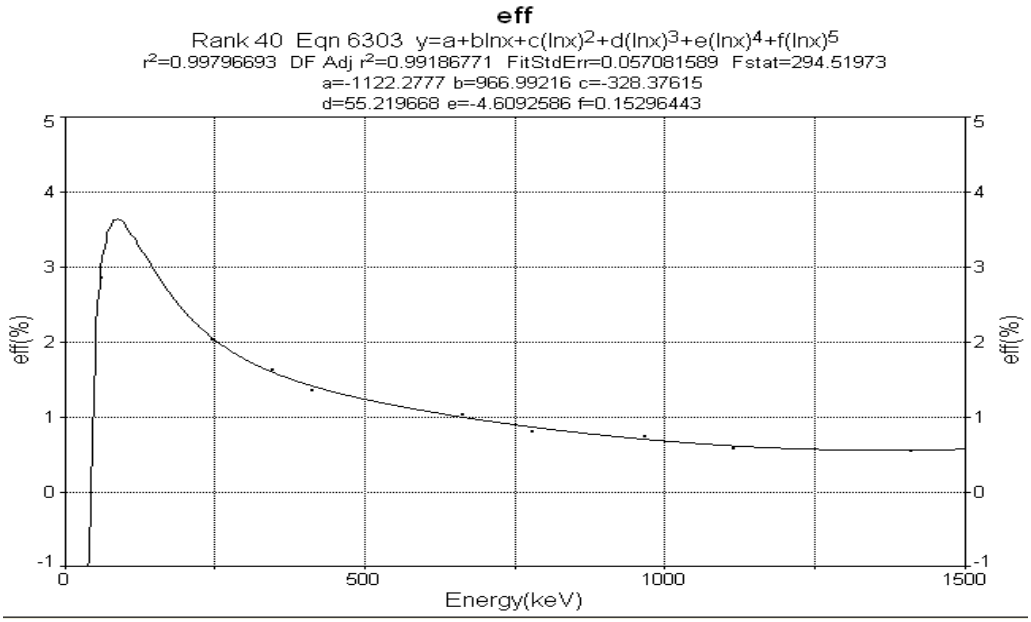

Fig. 2. HPGe detector efficiency versus gamma photon energy. The calibration curve has been shown as solid line. Squared points represent measured data.

$$Act = \frac{C_{net}}{\varepsilon(B.R.)t \times m} \times 100 \qquad (1)$$

Here C_{net} is the net area count, m (kg) is the sample mass, Act denotes the radionuclide activity in units of Bq/kg. ε is the absolute photo-peak efficiency at specific energy, and B.R.(%) is the branching ratio for the specific energy. The notation t(s) represents the counting time.

3 RESULTS AND DISCUSSION

Fungi identification results showed that all three examined species were basidiomycests.

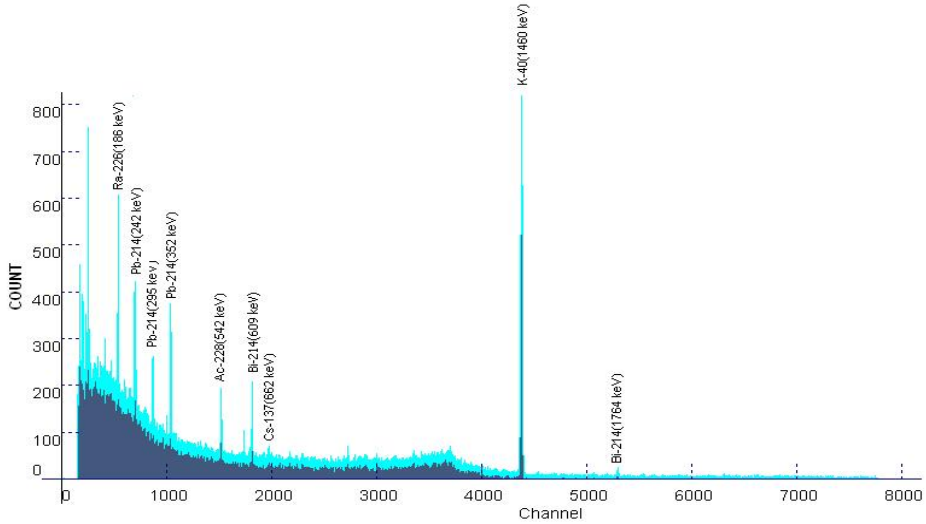

Fig. 3. Measured gamma spectrum for CAFC sample in Marinelli flask. Given energies in blankets are in units of keV.

Table1
Radionuclide concentrations (Bq/kg) in mushroom samples and their composts.

Sample code	^{238}U	^{235}U	^{232}Th	^{40}K	^{137}Cs
CBFC	<MDA	<MDA	7.45 ± 1.06	1166.12 ± 33.21	0.75±0.24
CAFC	3.4±0.81	<MDA	6.59±1.63	1326.36±11.93	1.97±0.27
CASC	<MDA	5.24±0.34	7.82±1.37	1428.27±13.71	1.27±0.25
EMFC	<MDA	<MDA	<MDA	1920.24±14.71	<MDA
EMSC	<MDA	<MDA	<MDA	1895.24±14.21	0.72±0.06
WCCM	<MDA	<MDA	<MDA	426.42±42.41	<MDA
WCMM	<MDA	<MDA	<MDA	1833.94±164.28	<MDA

Abbreviations: CBFC= Compost before first cultivation, CAFC=Compost after First cultivation, CASC=Compost after Second cultivation, EMFC =Edible mushroom first cultivated, EMSC = Edible mushroom Second, WCCM= Wild Cantharellus cibaruc, mushroom, WCMM = Wild Coprinus micaceuc mushroom.

* There is no data by the reason of lack of enough wild mushroom contents.

The cultivated mushroom was *Agaricus bispora*. The other two wild mushrooms were identified as *Coprinus micaceuc* and *Cantharellus cibarius*. The weighted mean values of the activity concentrations of ^{238}U, ^{235}U, ^{232}Th, ^{40}K and ^{137}Cs were provided in Table 1. The *^{137}Cs* activity concentration for the composts before the first cultivation (CBFC code sample) was 0.75 ± 0.24 Bq/kg that was near the MDA, while its amount increased after the first cultivation to 1.97± 0.27 (CAFC code sample). The reason can be due to adding soil cover to the compost in first cultivations of mushroom process. Table 1 shows that the radionuclide activity concentration in the soil is more than the compost produced in factory. However, exception was observed for ^{40}K that in the first cultivation mushroom increased to 1920.24 ±14.71 Bq/kg. In Comparison with the first cultivated mushrooms (EMFC code sample), the ^{137}Cs activity concentrations increased in the second cultivated mushrooms which may be due to consumed water contamination in *Agaricus bispora*. Regarding the lack of enough wild mushroom contents, the wild mushrooms were mixed with the locust tree (*Robonia pesudoacacia*) leaves for standard sample preparation.

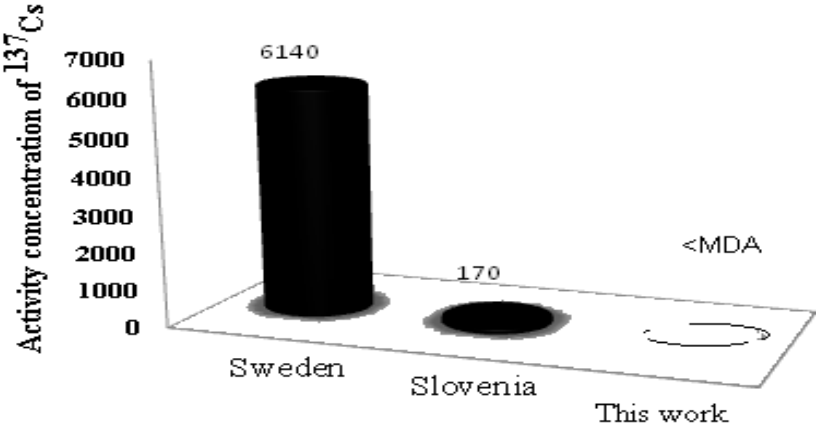

Fig.4. Present activity concentration of ^{137} Cs in *Cantharellus cibarius* and its comparison with those reported in Sweden and Slovenia (Kirchner et al., 1988; Byrne, 1988).

In the prepared sample, there were 124.5± 0.1 g and 33.0 ± 0.1 for *cantharellus cibarius* (WCCM code sample) and *coprinus micaceus* (WCMM code sample) respectively. The spectrum of the pure locust tree before mixing was analyzed and background radiation reduction was done. The HPGe gamma ray spectrometry system showed the minimum detectable activity (MDA) for ^{137}Cs, ^{238}U, ^{235}U and ^{232}Th in the leaves. As a consequence, only the wild mushrooms might contain the mentioned radio isotopes. Both kinds of wild mushrooms contain only ^{40}K higher than the MDA, which coprinus micaceus included about four times higher than cantharellus cibarius (see Table 1).

The radionuclide contents in the present mushrooms were less than the limit recommended by IAEA. For comparison, Sweden and Slovenia have been polluted more than the two studied regions of Iran (Fig. 4). The reason is that these countries are close to Ukraine and consequently their soils contain more artificial radionuclides amounts. In these regions, the radioactive contamination of wild plants and mushrooms are higher than the limit recommended by IAEA. As further lines of inquiry, researchers can be recommended to evaluate ^{137}Cs radionuclide activity in wild mushrooms growing in other regions of Iran.

4 CONCLUSION

As measured activity concentrations of the radionuclides in edible mushroom are close to or lower than the MDA (minimum detectable activity), the consumption of these mushrooms would impose no health consequences to consumers. Two kinds of wild mushrooms with the exception of ^{40}K did not contain higher than the MDA radionuclides.

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