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Accumulation of Natural Radionuclides by Some Edible Wild Mushrooms in Ekiti State, Southwestern, Nigeria

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Abstract

Activity concentrations of primordial radionuclides such as ^{40}K, ^{226}Ra and ^{232}Th were determined in edible mushrooms samples in Ekiti State Nigeria. The edible mushrooms collected are *Termitomyces striatus*, *Psathyrella atroumbonata*, *Termitomyces robustus*, *Pleurotus tuber-regium* and *Pleurotus squarrosulus*. The activity measurements were carried out by gamma spectrometry. The average concentrations of ^{40}K varied from 254.17 ± 46.78 to 416.07 ± 68.43 Bq·kg^{-1}, ^{226}Ra concentrations varied from 2.68 ± 0.82 to 21.64 ± 7.23 Bq·kg^{-1} and ^{232}Th concentrations varied from 8.57 ± 3.25 to 10.98 ± 4.31 Bq·kg^{-1}. The concentrations were converted to effective dose. Effective doses calculated were found to be below maximum permissible levels. Therefore, no health risk is envisaged for those that normally consumed these mushrooms.

Keywords

Mushrooms, Radioactivity, Gamma, Ekiti, Nigeria

1. Introduction

Anthropogenic (^{90}Sr, ^{137}Cs and ^{134}Cs) and primordial (^{40}K, ^{226}Ra and ^{232}Th) radionuclides are available in diverse environments such oceans, rivers, streams, soils, rocks, vegetable, animals and human body [1]. As a result, human being are constantly bombarding by radiation [2] due to human activities such as use of phosphate fertilizer in cultivation, burning of fossil fuels to generate heat and electricity, mining, milling operations and building materials [2] [3]. Food is one of the sources by which man is exposed to radiation. Therefore, radioactivity measurements in food stuffs (especially mushrooms) have widely reported in literature [3]-[11].

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Mushrooms are known to accumulate radionuclides efficiently [12]. However, there are no studies that determine primordial and anthropogenic radionuclides composition in edible mushrooms in Nigeria, therefore dearth of record abound. Mushrooms are highly rich in fiber, proteins, vitamins and minerals such as potassium, phosphorus, iron and sodium and are widely consumed in Ekiti State. As a result 95% of families in Ekiti and its environs consume up to 4 $kg \cdot y^{-1}$. Mushrooms are commonly found in cocoa plantation and thick forest. Samples are as seen in **Figure 1** and **Figure 2**. Farmers in Ekiti usually use chemicals and herbicides to control weeds, pests and fungi. It is imperative to ascertain the level of radionuclides in these mushrooms that could absorb them in the atmosphere though their surface cells of from soil through their roots.

Figure 1. *Termitomyces robustus*.

Figure 2. *Psathyrella atroumbonata*.

2. Materials and Methods

Sample Collection, Preparation and Counting

Edible mushrooms were obtained from different towns and villages in the state. Ten samples of each species were collected. The species are *Termitomyces striatus*, *Psathyrella atroumbonata*, *Termitomcyes robustus*, *Pleurotus tuber-regium and Pleurotus squarrosulus*. Fifty samples were collected in all. Samples were washed, cleaned and dried in air. They were then oven-dried at 80˚C for 16 hrs to remove the moisture content [13]. Dried samples of the same species were grounded together using a domestic blender. Thirty (30 g) of each dried mushrooms were placed in polyethylene beakers previously cleaned with 10% nitric acid. The beakers were then sealed and allowed to stand for at least 4 weeks so that the ^{226}Ra series was able to reach radioactive secular equilibrium. The activity concentrations of natural radionuclides ^{40}K, ^{226}Ra and ^{232}Th in the samples were determined using a NaI (Tl) γ-ray spectrometer system. The ^{226}Ra activity determination was based on 1.76 MeV gamma rays from ^{214}Bi. The activity of ^{232}Th was determined through its 2.62 MeV gamma rays from ^{208}Tl. The activity of ^{40}K (non-series) radionuclides was determined through its 1.46 MeV gamma rays. In situ measurement was carried out at the point of obtaining mushroom samples and after laboratory exposure using gamma scout detector that is calibrated across a wide scale (0.01 to 50 μSv·hr^{-1}). This was done to ensure safety at point of collection and laboratory. The values obtained are presented as shown in **Table 1**.

3. Results and Discussion

3.1. Radionuclides in the Mushrooms Samples

The average activity concentrations of ^{40}K, ^{226}Ra and ^{232}Th in five different edible mushrooms are presented in **Table 1**. The average activity concentration of ^{40}K, ^{226}Ra and ^{232}Th are found to be 339.05 ± 87.76 Bq·kg^{-1} (*Termitomyces robustus*)—416.07 ± 68.43 Bq·kg^{-1} (*Termitomyces striatus*), 2.68 ± 0.82 Bq·kg^{-1} (*Termitomyces striatus*)—21.64 ± 7.23 Bq·kg^{-1} (*Pleurotus squarrosulus*) and 8.57 ± 3.25 Bq·kg^{-1} (*Pleurotus tuber-regium*)—10.98 ± 4.31 Bq·kg^{-1} (*Pleurotus squarrosulus*) respectively. The highest concentrations were observed in *Termitomyces striatus* samples for ^{40}K, *Pleurotus squarrosulus* samples for ^{226}Ra and *Pleurotus squarrosulus* for ^{232}Th respectively. In general concentrations of ^{40}K are significantly higher in all the samples comparing to ^{226}Ra and ^{232}Th.

3.2. Internal Dose from Ingested Mushrooms.

The maximum permitted concentration level recommended by International Atomic Energy Agency (IAEA) is 10 kBq·kg^{-1} DM (dried matter) for mushrooms [14]. This limit must not be exceeded in all the samples. A possible risk of radioactivity for human being that consume these mushrooms is expressed by the effective dose (H) given in mSv·y^{-1}. The acceptable limit recommended by International Commission for Radiological Protection (ICRP) has been 1 mSv for adult yearly. The contribution to the annual effective dose to an adult that consume these species of mushrooms is calculated as follows [15].

$$H = Y \times Z \times IDCF \tag{1}$$

where Y is annual consumption of mushrooms in kg DM per person, Z is activity concentration in Bq·kg^{-1} DM, *IDCF* is the internal dose conversion factors of 6.2 × 10^{-3}, 0.28 × 10^{-3} and 0.23 × 10^{-3} μSv·Bq^{-1} of ^{40}K, ^{226}Ra and ^{232}Th respectively. **Table 2** shows the results of dose that will accrue to adult consuming these species of

Table 1. The average activity concentrations (Bq·kg^{-1}) of ^{226}Ra, ^{232}Th, ^{40}K and dose (μSv·hr^{-1}) rate taken before and after exposure (using gamma scout).

Concentration				Dose rate	
Species	^{40}K	^{238}U(^{226}Ra)	^{232}Th	Before Lab	After Lab
Termitomyces striatus	416.07 ± 68.43	2.68 ± 0.82	10.23 ± 3.76	0.14	0.13
Psathyrella atroumbonata	254.17 ± 46.78	18.75 ± 5.67	9.13 ± 4.02	0.15	0.13
Termitomyces robustus	339.05 ± 87.76	15.78 ± 4.98	14.31 ± 6.01	0.13	0.14
Pleurotus tuber-regium	401.44 ± 78.34	17.64 ± 5.98	8.57 ± 3.25	0.18	0.17
Pleurotus squarrosulus	369.84 ± 58.66	21.64 ± 7.23	10.98 ± 4.31	0.20	0.19

Table 2. The estimated daily intake and annual internal effective dose from ^{226}Ra, ^{232}Th and ^{40}K Consumption rate = 10 × 10^{-3} (kg·d^{-1}) Species Daily intake (Bq·d^{-1}) Effective dose (μSv·yr^{-1}).

	^{40}K	^{238}U(^{226}Ra)	^{232}Th	^{40}K	^{238}U(^{226}Ra)	^{232}Th
Termitomyces striatus	4.16	0.03	0.10	9.41	0.00	0.01
Psathyrella atroumbonata	2.54	0.19	0.09	5.75	0.02	0.01
Termitomyces robustus	3.39	0.16	0.14	7.67	0.02	0.01
Pleurotus tuber-regium	4.01	0.18	0.09	9.07	0.02	0.01
Pleurotus squarrosulus	3.70	0.22	0.11	8.37	0.02	0.01

mushrooms. The effective doses from ^{40}K, ^{226}Ra and ^{232}Th are found to be 5.75 (*Psathyrella atroumbonata*)—9.41 (*Termitomyces striatus*), ND (*Termitomyces striatus*)—0.02 (for the remaining species), 0.01 μSv·yr^{-1} for all the species. These values are still within acceptable limit.

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