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Naturally Occurring Radionuclides Present in Common Vegetables in Owerri, Imo State, Nigeria

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Abstract: Naturally occurring radionuclide materials are usually absorbed by plants through their root systems as nutrients, which in turn pose a radiation risk to humans when they consume the plants as food. This study evaluated the radionuclide risks from naturally occurring radionuclides in samples of commonly consumed vegetables in Owerri. Gamma ray spectroscopy was used to analyze and profile the ^{226}Ra, ^{232}Th and ^{40}K levels in the vegetable samples of African basil, water leaf, uziza leaf and bitter leaf which are commonly consumed vegetables in Owerri, south-eastern Nigeria. No artificial radionuclides were observed in all the vegetable samples. The ^{40}K level was found to be lower than the permissible level for all the vegetables while values above the permissible levels were observed for ^{226}Ra and ^{232}Th. We subsequently evaluated the Activity concentrations, Absorbed Gamma Dose Rate (D_R), Annual Effective Dose Equivalent (AEDE), Excess Lifetime Cancer Risk (ELCR). The range for the activity concentrations were, 193.86 to 391.05 for ^{40}K, 12.54 to 43.07 for ^{226}Ra and 91.92 to 111.27 for ^{232}Th. Although the absorbed dose (D_R) was almost twice the world average value, ELCR were lower than the permissible values indicating consumption safety for those who do not rely heavily on the consumption of these common vegetables.

Keywords: Radionuclide, Leafy Vegetables, Owerri, Cancer Risk, Dose

1. Introduction

For the derivation of several important minerals, dietary fibres and vitamins, humans rely heavily on vegetables [1]. And as such, vegetables have become one of the most important source of food supply and nourishments to humans. These vegetables are usually consumed either in their raw states, cooked or roasted. While washing and application of heat can readily take care of some of the biological contaminants found in vegetables, they do so little in taking care of the chemical contaminants, which by soil nutrient, is an integral part of the chemical buildup of the plants.

The African basil (*Ocimum basilicum*), water leaf (*Talinum triangulare*), Uziza leaf (*Pipe guineense*), and Bitter leaf (*Vernomia amygdalina*) belong to the leafy vegetables and are usually prepared as savory dishes. Their extracts have also been used as herbal remedies against some dietary disorders [2, 3] and also as skin care products [4]. Some of these leafy vegetables have also been reported to possess strong antimicrobial effects [5-7]. Hence, they are in high demand for everyday use.

There have been several studies on radionuclide contaminants of common food stuffs in Nigeria, Amakom *et al.*, [8] investigated the gross alpha and beta activity concentrations in cassava and fluted pumpkin; Arogunjo *et al.*, [9], determined the radionuclide concentrations from major cereals and tubers consumed in Nigeria. In separate studies undertook by Jibiri *et al.*; Arogunjo *et al.*, [10, 11], in a tin mining area; high levels of radionuclides were reported to have been accumulated in the food samples they worked on.

Apparently, radionuclides detected in plants are originally contained in soil from where they get translocated via the root system to different plants' part or transported either by direct fallout of radionuclides and re-suspension of contaminated soils followed by deposition on plant leaves or soils within the vicinity of the plants [12]. Sometimes, man-made radionuclides contaminate the food chain as a result of fallout from nuclear weapons tests in the atmosphere or from routine and accidental release of nuclear wastes as reported by IAEA [13]. As the spatial distribution of radionuclides varies with respect to the parent soils from region to region [14], so also, their uptake by plants varies from place to place.

The phytochemical properties of the vegetables considered in this work have been established in many research works, but there's sparse data on the radionuclide content of these vegetables. Thus, assessment of the radionuclides concentration and distribution in these leafy vegetables are of particular interest; as it will enhance the knowledge on risk posed by radiation exposure that could result from incorporating such items into our dietary requirements. This work investigates the levels of naturally occurring radionuclide materials (NORM) in samples of African Basil, Water leaf, Bitter leaf and Uziza leaf collected in a popular market of Owerri, Imo state, south-eastern Nigeria. This was done to assess the radio-toxicity associated with the ingestion of these vegetables as part of human diets.

2. Materials and Methods

Four types of vegetables (African Basil, Water leaf, Bitter leaf and Uziza leaf) used in this study were obtained from a local market in Owerri. Each vegetable sample was properly rinsed with distilled water to remove extraneous materials that may have been deposited on their outer surfaces. The vegetables were further sliced and placed in a properly labeled crucible dishes and dried to a constant weight in the laboratory using the Gallenkamp oven at a temperature of 60°C.

To ensure homogeneity, the dried samples were crushed and pulverized to fine powder using mortar and pestle. Each of the pulverized samples was weighed by the use of an electronic balance and placed in a labeled container and weighed. The samples were kept in an air-tight plastic container, which had been washed thoroughly with soap and rinsed with distilled water and incubated for a period of four weeks in order to attain radioactive equilibrium between parents and progenies.

The gamma ray spectroscopy was performed with the aid of the NaI (Tl) spectrometer housed at the Center for Energy Research and Training, Ahmadu Bello University, Zaria, Nigeria. The scintillation detector has an active area of 3×3 inches, energy resolution of 7.9% and efficiency of 4.6% at the 662KeV.

The calculation of the specific activity for each of the detected photo peak was performed in $Bqkg^{-1}$ by the use of equation 1 [15]

$$A_r\left(\frac{Bq}{Kg}\right) = \frac{N - N_0}{I_Y \in Mt} \tag{1}$$

Where

A_r: radionuclides Specific activity in the sample

N: The net counts of a given peak for a sample.

N_0: The background of the given peak.

I_Y: The number of gamma photons per decay.

$\in$: The detector efficiency at the specific gamma ray energy

M: The sample mass.

t: Sample's measurement time.

The annual effective dose was also calculated considering ICRP metabolic model [16].

$$D_{rf}\left(\frac{Sv}{Y}\right) = \sum C_r A_{rf} R_f \tag{2}$$

Where

D_{rf}: The annual effective dose

A_{rf}: The specific activity of the nuclide

R_f: The consumption rate of the vegetables

C_r: The effective dose conversion factor of the nuclide

Excess Lifetime Cancer Risk (ELCR) was calculated using the following equation,

$$\text{ELCR} = \text{AEDE} \times \text{DL} \times \text{RF} \tag{3}$$

Where AEDE is the Annual Effective Dose Equivalent, DL is the Average Duration of Life (estimated to 54 years) and RF is the risk factor (Sv-1). For stochastic effect, ICRP uses RF as 0.05 for public [17].

Table 1. *Activity Concentration of Radionuclide in Vegetable Samples.*

Sample	^{40}K (Bq/kg)	^{226}Ra (Bq/kg)	^{232}Th (Bq/kg)	Reference
African Basil	193.86 ± 5.36	12.54 ± 1.03	111.27 ± 3.14	This work
Uziza leaf	391.05± 9.11	43.07 ± 1.95	96.37 ± 3.46	This work
Bitter leaf	371.53 ± 8.58	39.87 ± 2.23	91.92 ± 4.08	This work
Ukazi leaf	262.77 ± 5.47	38.99 ± 1.91	94.60 ± 3.22	This work
Bitter leaf	103.26±6.08	8.63±3.45	6.58±0.76	[18]
Water leaf	118.96±22.43	9.67±8.53	7.87±1.89	
Lagos spinach	68.62±5.22	1.59± 0.43	0.31±0.05	
African spinach	90.692±5.87	1.622±0.44	0.382±0.09	[19]
Spring onion	41.66±3.09	2.30±0.60	0.25±0.06	
*UNSCEAR (2000)	400	35	30	

*UNSCEAR, 2000 Permissible values

Table 2. *Radiological Risk Values for Vegetables.*

Sample	D_R (nGy/h)	AEDE (mSv/y)	ELCR (×10^{-3})
African Basil	81.0894	0.8195	0.2687
Uziza leaf	94.4149	0.1159	0.3129
Bitter leaf	89.4405	0.1093	0.2965
Ukazi leaf	86.1141	0.1057	0.2854
Mean	87.7647	0.1079	0.2909
*UNSCEAR (2000)	55	0.48	2.9 ×10^{-3}

*UNSCEAR, 2000 Permissible values

3. Results and Discussions

Table 1 summarizes the activity concentration (in Bq/kg) for the radionuclides content of the leafy vegetables considered in this work. The radionuclide contents ranged from 193.86 to 391.05 Bq//kg for ^{40}K, 12.54 to 43.07 Bq/kg for ^{226}Ra and 91.92 to 111.27 Bq/kg for ^{232}Th. From table 1, the ^{40}K from all the vegetables were less than the UNSCEAR permissible level for leafy vegetables, while with the exclusion of the African Basil, the radionuclide content for ^{226}Ra and ^{232}Th from the vegetables were all higher than the UNSCEAR permissible levels. In all cases, Uziza leaf had the highest activity concentration while African Basil had the least. The values obtained in this work were also observed to be higher than what was obtained in the other parts of the country by Ibitola *et al*., and Adedokun *et al.* [18, 19]. Thus suggesting that the amount of radionuclides in the plant system is not only influenced by the geological formation and composition of the soil on which a given plant grows, but also the plant species.

The values obtained for the annual effective dose equivalent (AEDE) was observed to fall within the UNSCEAR permissible limit of 0.48 [20]. Also, the calculated value for the excess lifetime cancer risk (ELCR) varied between 0.2×10^{-3} and 0.3×10^{-3} with a mean value of 0.2×10^{-3}. When compared with the recommended safe limit of 2.9×10^{-3} by UNSCEAR [20], it could be inferred that the ELCR values would not lead to cancer and external diseases such as erythema, skin cancer and cataracts.

4. Conclusions

The radioactivity concentration of ^{40}K, ^{226}Ra and ^{232}Th in common vegetables consumed in Owerri and its environs were determined in this study. Except for the activity concentration of ^{40}K which was found to be lower than their permissible values, the values obtained for ^{226}Ra and ^{232}Th were higher than the acceptable values, probably as a result of the geographical, geological and plant species factors. The activity concentrations, gamma absorbed dose rates (D_R), annual effective dose equivalent (AEDE), excess lifetime cancer risk were all calculated and it suffices to say that these vegetables have a good level of consumption safety when compared with the world permissible values.

Conflicting Interest

The authors wish to categorically state that there is no conflicting interest in this article.

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