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Potential Radiological Impact of Consumption of Fluted Pumpkin (*Telfairia occidentalis*) Cultivated in Southeast Nigeria

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Abstract: The radionuclides present in Fluted Pumpkin (*Telfairia occidentalis*) cultivated and consumed in Southeast Nigeria were assessed and their activity concentration determined to assess the potential radiological impact of consumption of the vegetable as part of the daily diet. The radioactivity concentration of ^{238}U, ^{232}Th and ^{40}K in the vegetable samples were ranging from 18.06±6.00 to 43.08±9.07 Bq/kg for ^{238}U (mean = 28.68±3.62 Bq/kg), 13.41±3.01 to 17.79±3.68 Bq/kg for ^{232}Th (mean = 15.41±1.62 Bq/kg) and 219.13±10.64 to 354.04±10.15 Bq/kg for ^{40}K (mean = 251.84±8.07 Bq/kg). There was no anthropogenic radionuclide detected. The annual intake of ^{238}U and ^{232}Th from consumption of Fluted Pumpkin in the locality under study was range from 3.6-8.6 Bq/yr (mean = 5.7 Bq/yr) and 2.7-3.6 Bq/yr (mean = 3.1 Bq/yr). The committed effective dose was 0.25 μSv for ^{238}U and 0.71 μSv for ^{232}Th. The consumption of Fluted Pumpkin can lead to enhanced dietary intakes of thorium series radionuclide when considered against the intakes from other food materials.

Key words: Fluted pumpkin, Nigeria, radioactivity, radiological impact, vegetables

INTRODUCTION

Vegetables are important part of healthy eating for humans and source of micro-nutrients, vitamins and fibers. In Africa indigenous vegetables remain popular in rural and urban areas where they are often considered to be more nutritive than exotic vegetables (Horsfall and Spiff, 2005).

Telfairia occidentalis commonly called Fluted Pumpkin is an important leaf and seed vegetable indigenous to Southeast Nigeria (Oyekunle and Oyerele, 2012). It probably originated in southeast Nigeria and distributed by the Igbos who have been cultivating this crop for ages (Akoroda, 1986; Schippers, 2000). Fluted Pumpkin leaf has high nutritional, medicinal and industrial values rich in protein (29%), fat (18%), minerals and vitamins (20%) (Akanbi *et al*., 2006).

In order to maintain all year round supply of the vegetable, farmers apply different types of soil amendments such as crop wastes, farmyard manure, poultry wastes (Adediran *et al*., 2003) and inorganic fertilizers (Awodun, 2007; Akanbi *et al*., 2010; Ojetayo *et al*., 2011). These fertilizer types improve soil's physical, chemical and biological conditions to enhance yield. The inorganic fertilizers, which are largely phosphate-based, are sources of transfer of natural radionuclides to the environment (UNSCEAR, 2000). These radionuclides arise mainly from the primordial radionuclides of Uraniun-238 (^{238}U), Thorium-232 (^{232}Th) and Potassium-40 (^{40}K) series and their decay products (Jazzar and Thabayneh, 2014). The radionuclides are released to the soil, absorbed by the roots, transferred to the shoot and ultimately ingested by man through the food chain (Guivarch *et al*., 1999; Okeji *et al*., 2012). Exposure of humans to radiation through ingestion of natural radionuclides may result to somatic and genetic diseases.

This study was aimed at assessing the natural radioactivity present in Fluted Pumpkin cultivated in Southeast, Nigeria in order to determine its contribution to radiation dose to man through its consumption. The knowledge of intake of ^{238}U and ^{232}Th via the food chain is necessary to estimate the uptake and retention of these radionuclides in the human body (Okeji *et al*., 2012). Fissene *et al*. (1987) and Shiraishi *et al*. (2000) identified vegetables as one of the contributors to daily intakes of ^{238}U and ^{232}Th.

MATERIALS AND METHODS

The Southeast Nigeria, location of the present study, is made up of five states namely: Abia, Anambra, Ebonyi Enugu and Imo States. For anonymity the states have been assigned letters A-E in no particular order.

Sample collection and preparation: Fluted Pumpkin vegetable were bought from five local markets randomly selected from each state. In all a total of 25 samples were obtained. As soon as the vegetable samples were bought, they were washed to remove adhering soils and labeled accordingly. During preparation the vegetables were carefully washed, air dried before being dried in an oven at 105°C. The dried samples were ground and passed through a 2 mm sieve. They were then packed in empty Marinelli beakers measuring 8.0 cm diameter by 6.4 cm height designed to fit into the sodium iodide gamma spectrometer counting chamber. Prior to being packed, the containers were thoroughly washed in 0.1 m hydrochloric acid, rinsed in distilled water and dried to avoid contamination by radioactive particles. The empty containers were weighed before the vegetable samples

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were packed and hermetically sealed. The sealed samples were weighed again to obtain the net weight of the vegetable samples and then left for 28 days to allow short-lived radionuclides of ^{238}U and ^{232}Th to attain secular equilibrium.

Gamma spectrometric analysis: The activity counting was carried out using Sodium iodide NaI (TI) based gamma-spectrometric system. The system consists of 76 x 76 mm NaI (TI) detector manufactured by Canberra Inc. connected to a multichannel analyzer through a preamplifier base and interphased to an IBM personal computer. The detector has a resolution of about 8% at 662 kev for ^{137}Cs. This value is capable of distinguishing the gamma ray energies likely to be encountered in the measurement of the samples. Energy calibration was carried out using standard source from IAEA with photo peak of known energies in the range of 200 to 2500 kev. Efficiency calibration was achieved using standard reference source (IAEA 375) whose energies and activities are known. Each sample was counted for 36000 seconds (10 h) and the data acquired automatically by SAMPO 90 software program. The software searches for the peak, evaluates the peak position in the energy spectrum, identifies the radionuclide by means of a radionuclide library. It calculates the net peak areas after subtracting the background count. The activity concentration in selected units is subsequently displayed. The empty Marinelli beaker was counted for the same period of time and subtracted from the values.

RESULTS AND DISCUSSION

The radionuclides identified in the Fluted Pumpkin (*Telfairia Occidentalis*) cultivated in Southeast Nigeria were those from the naturally occurring radionuclides of ^{234}U, ^{232}Th and ^{40}K. The mean activity concentration of radionuclides in vegetable samples from the five Southeastern states was ranging from 18.06±6.00 to 43.08±9.07 Bq/kg for ^{238}U (mean = 28.68±3.62 Bq/kg), 13.41±3.01 to 17.79±3.68 Bq/kg for ^{232}Th (mean = 15.41±1.62 Bq/kg) and 219.13±10.64 to 354.04±10.15 Bq/kg for ^{40}K (mean = 251.84±8.07 Bq/kg). There was no anthropogenic radionuclide detected (Table 1). The mean activity concentration of ^{238}U in Fluted Pumpkin cultivated and consumed in Southeast Nigeria is higher than 24 Bq/kg seen in vegetable in the US (Fissene *et al*., 1987) and the world reference value in leafy vegetables is 20 Bq/kg (UNSCEAR, 2000). However, the mean activity of ^{232}Th is within the world reference value of 15 Bq/kg (UNSCEAR, 2000).

The annual intake of ^{238}U and ^{232}Th radionuclides from consumption of Fluted Pumpkin in the locality under study was ranging from 3.6-8.6 Bq/yr (mean = 5.7 Bq/yr and 2.7-3.6 Bq/yr (mean = 3.1 Bq/yr Radionuclide intake is 'activity concentration of radionuclides multiplied by usage or dietary intake' (Akinloye *et al*., 1999). The usage factor of vegetable in Nigeria is 0.55 x 10^{-3} kg per day or 0.2 kg per year (FAO, 1992). This value is adopted by the authors due to lack of site specific data. According to NCRP (1984), when the food consumption pattern of a population is not unusual, the general consumption pattern is applied.

Table 1: Mean activity concentration of radionuclides in Telfairia occidentalis

	Activity concentration (Bq/kg ± SD)		
Code	^{238}U	^{232}Th	^{40}K
A_1-A_5	34.82±5.42 to 51.34±12.74	16.38±3.98 to 19.20±3.5	210.88±11.26 to 371.20±19.96
Mean	43.08±9.07	17.79±3.68	291.04±1.56
B_1-B_5	23.64±7.43 to 25.51±11.04	16.85±2.25 to 18.44±3.48	292.05±8.92 to 416.02±11.37
Mean	24.48±9.23	17.64±3.00	354.04±10.15
C_1-C_5	15.69±4.88 to 20.42±7.12	9.68±2.62 to 17.74±3.75	90.52±2.41 to 140.05±0.76
Mean	18.06±6.00	13.71±3.16	115.29±3.64
D_1-D_5	29.17±6.89 to 33.48±12.52	13.04±2.68 to 13.79±3.34	263.28±5.36 to 279.70±2.86
Mean	31.33±9.70	13.41±3.01	279.70±2.86
E_1-E_5	24.30±9.39 to 28.50±57.12	9.98±1.97 to 18.82±4.01	177.15±8.54 to 261.11±12.79
Mean	26.40±7.55	14.52±3.00	219.13±10.6
Mean	28.68±3.62	15.41±1.62	251.84±8.07

The mean value of annual intake of ^{238}U from Fluted Pumpkin (5.7 Bq/yr) was noted to be within the reference level which is 5.7 Bq/yr. However, the mean value of annual intake of ^{232}Th from the vegetable (3.1 Bq/yr) was about twice the reference value of 1.7 Bq/yr (UNSCEAR, 2000).

The committed effective dose to members of the public due to ^{238}U and ^{232}Th radionuclides from consumption of the Fluted Pumpkin vegetables is given by:

- $E_U = I_U \times e(g)_U$ Misdaq *et al.* (2000)
- $E_{Th} = I_{Th} \times e(g)_{Th}$ Rzama *et al.* (1994)

where, I_U(Bq) and I_{Th}(Bq) are the annual intakes of ^{238}U and ^{232}Th, respectively, $e(g)_U$ and $e(g)_{Th}$ are the ICRP ingestion dose coefficients for ^{238}U and ^{232}Th radionuclides respectively (ICRP, 1996). The ICRP values of ingestion dose coefficient for ^{238}U [$e(g)_U$] and ^{232}Th [$e(g)_{Th}$] radionuclides for age groups above 17 years are 4.5×10^{-8} Sv/Bq and 2.3×10^{-7} Sv/Bq. The committed effective dose from annual intake of Fluted Pumpkin was 0.25 µSv for ^{238}U and 0.71 µSv for ^{232}Th. The value obtained for ^{238}U is within the reference value of 0.25 µSv while the value due to ^{232}Th is about twice the reference value of 0.36 µSv (UNSCEAR, 2000). The consumption of Fluted Pumpkin can lead to enhanced dietary intakes of thorium series radionuclide when considered against the intakes from other food materials.

Potassium (^{40}K) is uniformly distributed in the body following intake in foods and its concentration in the body is under homeostatic control. For adults, the body content of potassium is about 0.18% and for children, about 0.2% (UNSCEAR, 2000).

Conclusion: Ingestion intake of natural radionuclides depends on the consumption rates of food and water and on the radionuclide concentrations (UNSCEAR, 2000). The concentrations of the natural radionuclides in the samples of Fluted Pumpkin cultivated in Southeast, Nigeria has ^{234}U values higher than world reference in vegetables while ^{232}Th values were observed from our study to be within the world average in vegetables. The value of annual intake of ^{238}U in the Fluted Pumpkin (5.7 Bq/yr) is within the reference value of 5.7 Bq/yr. However, the annual intake of ^{232}Th in the vegetable (3.1 Bq/yr) was twice the reference value of 1.7 Bq/yr (UNSCEAR, 2000). Although it may not be possible to draw direct relationship between radionuclides in vegetables and the health detriments resulting from their intake, there is need to constantly monitor radioactivity in vegetables that form part of the daily diet to ensure that it is within the acceptable range.

Conflict of interest: The authors declare that there was no conflict of interest.

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