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Assessment of Radioactivity Concentrations and Effective of Radionuclides in Selected Fruits from Major Markets at Ijebu – Ode in Ogun State, Southwest of Nigeria

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ABSTRACT: Natural Radionuclides are elements that are found in the air, water and soil. They find their ways in to the plants through the leaves and absorption of nutrients and water from the soil through the roots. Intake of fruits is very essential for human beings as part of balance diet. The concentrations of natural radionuclides in some fruits from three major markets at Ijebu- Ode town in Nigeria were determined and annual committed effective dose to the consumers was also determined. The gamma spectrometry method was used for the analysis. The highest concentrations of ^{40}K, ^{238}U and ^{232}Th were from pineapple of value 102.36 ± 10.81Bqkg^{-1}, orange of value 12.18 ± 4.36Bqkg^{-1} and mango of value 8.01 ± 3.25 Bqkg^{-1} respectively. The average annual committed effective dose of the natural radionuclides to the consumers was calculated to be 0.11mSvyr^{-1}, which is below the limit of 0.3mSvyr^{-1} recommended globally. This indicates that the ingestion of these radionuclides through the consumption of these fruits has no radiological health hazard to the consumers.

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Natural Radionuclides are elements that are found in the air, water and soil. They find their ways in to the plants through the leaves and absorption of nutrients and water from the soil through the roots. Intake of fruits is very essential for human beings as part of balance diet. All living things are continuously exposed to ionizing radiation from Naturally Occurring Radioactive Materials (NORM). NORM existing in soil could pose potential health risk (Wilson, 1993), especially when aided by natural processes such as weathering deposition and wind erosion (Elles *et al.*, 1997). Naturally Occurring Radioactive Materials (NORMs) have always been present in every part of the earth and in the tissue of all living beings. Natural radionuclides such as ^{238}U, ^{232}Th and ^{40}K can be found almost everywhere; in soil, public water supplies, oil and atmosphere thereby subjecting human beings to reasonable exposure (Ali, 2008; Varier, 2009). The artificial sources of radionuclides are largely due to medical and industrial activities. Studies on radiation levels and radionuclide distribution in the environment provide vital radiological baseline information. Such information is essential in estimating human exposure from natural and man-made sources of radiation and necessary in establishing rules and regulations relating to radiation protection (Quindos *et al.*, 1994). The ingested radionuclides could be concentrated in certain parts of the body for example ^{238}U accumulated in human kidney and lungs, ^{232}Th in liver, skeleton tissue and lungs and ^{40}K in muscles (Tawalbeh *et al*, 2012). The accumulation of these radionuclides in any organ in the body will affect the health condition which may result to inducing various forms of diseases, weakening the immune system and also contributing to increase in mortality rate. Natural sources of radiation a combination of cosmic and terrestrial radiation represent the major part of radioactivity in the food chain. The radionuclides potassium-40, uranium-235 and -238 as well as products from these decay series such as radon-222, radium-226 and thorium-232 can be dated back to the beginning of the earth. Radionuclides such as ^{40}K, ^{226}Ra that occur naturally in soil are incorporated metabolically into plants and ultimately find their way into food and water (Eisenbud and Gesell, 1997).

Preliminary investigation of naturally occurring radionuclides in some traditional medicinal plants used in Nigeria for the treatment of some diseases

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by Njinga *et al* (2015) revealed that the average annual committed effective doses due to the ingestion of ^{226}Ra, ^{232}Th and ^{40}K from the plants by the consumers ranged from $0.00426 mSvyr^{-1}$ to $0.00686 mSvyr^{-1}$ with an average value of $0.00538 mSvyr^{-1}$ which is below the worldwide average value of $0.3 mSvyr^{-1}$ for an individual provided in UNSCEAR 2000 report indicating that the consumers are radiologically safe. The research work done by Giri *et al* (2013) concerning foodstuffs and water ingestion by human beings in India from uranium mining area of the study area revealed that the ingestion dose was below the dose limit of $1 mSvyr^{-1}$ for public exposure in planned exposure situation as recommended by ICRP (1992) indicating also that the people are radiologically safe. Also, the study of natural radionuclides concentration levels was carried out by Sowole (2011) along with their dose rates in some species of prawn. The average dose rate of all the radionuclides in the prawns was calculated to be $2.81 \times 10^{-3} mGyhr^{-1}$ which was below the limit of $0.4 mGyhr^{-1}$ recommended by NCRP (1991) as reported by Blaylock *et al* (1993) and therefore do not pose radiological health problem to the aquatic animals.

This research work is to determine the radioactivity concentrations, annual committed effective doses of ^{40}K, ^{238}U and ^{232}Th, along with average annual committed effective dose from some fruits purchased from major markets at Ijebu - Ode in Ogun State, Southwest of Nigeria to consumers.

MATERIALS AND METHODS

The method of gamma spectrometry was adopted for the analysis of the samples collected to obtain data on ^{40}K, ^{238}U and ^{232}Th. Twelve (12) samples of edible fruits: orange of scientific name *citrus sinensis*, pineapple having scientific name *Ananas comosus*, banana of scientific name *musa balbisiana* and mango having scientific name *mangifera indica* from three major markets at Ijebu - Ode: Okeaje, New Market and Itaale of the study area were purchased. They were rinsed with distilled water to avoid contamination, and cut in to pieces, after which they were oven dried at 80^0C (Akinloye *et al*, 1999), grinded, weighed, packed 98.0g by mass in plastic containers and carefully sealed and kept for twenty-eight days (28) to establish secular radioactive equilibrium between the natural radionuclides and their respective progenies.

The method of gamma spectrometry was adopted for the analysis of the samples purchased to obtain data on ^{40}K, ^{238}U and ^{232}Th. The spectrometer used was a Canberra lead shielded 7.6cm x7.6cm NaI (Tl) detector coupled to a multichannel analyzer (MCA) through a preamplifier base. The resolution of the detector is about 10% at 0.662MeV of ^{137}Cs. According to Jibiri and Farai (1998) the value is good enough for NaI detector to distinguish the gamma ray energies of most radionuclides in samples. For the analysis of ^{40}K, ^{238}U and ^{232}Th, the photo peak regions of ^{40}K (1.46 MeV), ^{214}Bi (1.76 MeV) and ^{208}TI (2.615 MeV) were respectively used. The cylindrical plastic containers holding the samples were put to sit on the high geometry 7.6cm x 7.6cm NaI (TI) detector. High level shielding against the environmental background radiation was achieved by counting in a Canberra 10cm thick lead castle. The counting of each sample was done for 10hrs because of suspected low activities of the radionuclides in the samples. The areas under the photo-peaks of ^{40}K, ^{238}U and ^{232}Th were computed using the Multichannel Analyzer system.

Theoretical Consideration and Calculations: The concentrations of the radionuclides were calculated based on the measured efficiency of the detector and the net count rate under each photopeak over a period of 10 hours using equation 1.0

$$C = \frac{N(E_\gamma)}{\varepsilon(E_\gamma) I_\gamma M t_c} \qquad 1.0$$

Where: $N(E_\gamma)$ = Net peak area of the radionuclide of interest, $\varepsilon(E_\gamma)$ = Efficiency of the detector for the γ-energy of interest, I_γ = Intensity per decay for the γ-energy of interest, M = Mass of the sample, t_c = Total counting time in seconds (36000s).

In addition, the annual committed effective dose (ACED) for ingestion of NORMs in fruits is calculated using the expression (Lordford *et al*, 2013):

$$ACED = C \times DCF \times CR \qquad 2.0$$

Where: C = Concentration of each radionuclide, DCF = Dose conversion factor for ingestion obtained from UNSCEAR (2000) and CR = Consumption rate of intake of NORMs from the fruits

RESULTS AND DISCUSSION

The concentrations of the natural radionuclides in the fruits from the markets are shown in table 1, the highest for ^{40}K, ^{238}U and ^{232}Th are $102.36 \pm 10.81 Bqkg^{-1}$ from pineapple, $12.18 \pm 4.36 Bqkg^{-1}$ from orange and $8.01 \pm 3.25 Bqkg^{-1.}$ from mango respectively. The mean concentrations of ^{40}K for all the samples was obtained to be 78.51 ± 8.66 $Bqkg^{-1}$, 9.24 ± 3.40 $Bqkg^{-1}$ for ^{238}U and 6.34 ± 2.29 $Bqkg^{-1}$

for ^{232}Th. No artificial radionuclide was detected in all the samples. The highest ACED to the consumers for ^{40}K was obtained to be 0.091mSvyr^{-1} with mean value of 0.070mSvyr^{-1} as shown in table 2. Also, highest ACED to the consumers for ^{238}U was obtained to be 0.079mSvyr^{-1} with mean value of 0.060mSvyr^{-1} and the highest for ^{232}Th was 0.265 mSvyr^{-1} with mean value of 0.197mSvyr^{-1}. These values are similar to those obtained by Harb (2015). The average for all the radionuclides was calculated to be 0.11mSvyr^{-1}. All the values obtained are below the world average recommended limit of 0.3mSvyr^{-1} (UNSCEAR, 2000) for ingestion of natural radionuclides.

Table 1: Radioactivity concentrations of natural radionuclides in fruits samples

SAMPLE LOCATION	FRUIT	RADIOACTIVITY CONCENTRATION (Bqkg^{-1})		
		^{40}K	^{238}U	^{232}Th
Okeaje	Orange	65.34 ± 8.36	12.18± 4.36	6.35 ± 2.17
Okeaje	Pineapple	72.65 ± 9.04	8.35 ± 2.08	7.24 ± 1.08
Okeaje	Banana	68.37 ± 8.15	10.29 ± 3.16	6.92 ± 2.04
Okeaje	Mango	71.26 ± 9.46	7.65 ± 2.65	8.01 ± 3.25
New market	Orange	82.81 ± 10.25	7.34 ± 3.08	5.36 ± 2.06
New market	Pineapple	91.26± 8.37	9.57 ± 4.36	6.28 ± 1.86
New market	Banana	77.15 ± 6.48	11.04 ± 3.87	7.13 ± 2.49
New market	Mango	69.64 ± 7.85	8.65 ± 2.74	4.57 ± 2.31
Itaale	Orange	68.49 ± 8.02	8.96 ± 3.02	4.51 ± 1.97
Itaale	Pineapple	102.36 ± 10.81	11.38 ± 4.96	7.46 ± 2.86
Itaale	Banana	82.42 ± 7.65	7.46 ± 2.84	5.42 ± 2.47
Itaale	Mango	90.38 ± 9.47	8.04 ± 3.67	6.85 ± 2.94
	RANGE	65.34 – 102.36	7.34 – 12.18	4.51 – 8.01
	MEAN	78.51 ± 8.66	9.24 ± 3.40	6.34 ± 2.29

Table 2: Calculated Annual Committed Effective Dose to Consumers

SAMPLE LOCATION	**FRUIT**	**^{40}K, ACED(mSvyr^{-1})**	**^{238}U, ACED(mSvyr^{-1})**	**^{232}Th, ACED(mSvyr^{-1})**
Okeaje	Orange	0.058	0.079	0.210
Okeaje	Pineapple	0.065	0.054	0.240
Okeaje	Banana	0.061	0.067	0.229
Okeaje	Mango	0.064	0.050	0.265
New market	Orange	0.074	0.050	0.178
New market	Pineapple	0.082	0.062	0.208
New market	Banana	0.069	0.072	0.236
New market	Mango	0.062	0.056	0.151
Itaale	Orange	0.061	0.058	0.149
Itaale	Pineapple	0.091	0.074	0.247
Itaale	Banana	0.074	0.048	0.180
Itaale	Mango	0.081	0.052	0.227
	MEAN	**0.070**	**0.060**	**0.197**

Conclusion: The radioactivity concentrations, annual committed effective doses of ^{40}K, ^{238}U and ^{232}Th, along with average annual committed effective dose from some fruits purchased from major markets at Ijebu - Ode in Ogun State, Southwest of Nigeria to consumers had been determined from the research work. Thus all the values obtained are below the world average recommended limit for ingestion of natural radionuclides. In conclusion, the results obtained indicate that the consumption of the fruits by the people in the study area does not pose any significant radiological health risk to them.

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