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RADIOACTIVITY CONTENT SURVEILLANCE ON CANNED FOOD PRODUCTS IN NIGERIA

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ABSTRACT

The radionuclides surveillance on imported can food products in Nigeria market has been investigated using High purity Germanium detector. The radioactivity concentrations of ^{226}Ra, ^{232}Th, ^{40}K, ^{210}Pb and ^{137}Cs in selected brands of imported canned food products categorized into staple foodstuffs, beef and seafood were analyzed. The results obtained for staple foodstuffs shows a mean activity value of 12.33±3.68, 12.35±4.62, 51.48±15.12, 2.65±0.18 and 0.61±0.27 Bq kg^{-1} for ^{226}Ra, ^{232}Th, ^{40}K, ^{210}Pb and ^{137}Cs respectively, while in beef food products, it is 14.41±4.79, 14.12±4.83, 50.44±14.80, 1.11± 0.07 and 0.32±0.20 Bq kg^{-1} respectively, and for seafood products it is 17.95±5.71, 16.24±5.48, 61.65±18.07, 1.17±0.13 and ND Bq kg^{-1} respectively. The overall results indicate that the natural radioactivity in the three categories of canned foodstuffs examined are well below the UNSCEAR and other regulatory bodies recommended permissible limits. The presence of ^{137}Cs in some samples potent some degree of heavy metal contamination of those foodstuffs. The computed dose to essential organs and tissues indicates a highest dose level of 0.2 mSvy^{-1} which is well within the 1mSvy^{-1} recommended permissible level of the public. The calculated collective effective dose equivalent revealed that 97,463,16 of the total population are exposed to radiation from ingestion of the canned foods with adults most impacted. The total health detriment indicates radiological risk ratio of 1:2238 for infants, 1:2583 for children and 1:4238 for adults. From the estimated cost-detriment, it is obvious that the economic benefits which is directly proportional to cost of purchase and importation put at about nine billion US dollars annually derived from consuming these imported canned food products is far above the health detriment.

Keywords: Radioactivity surveillance, canned food, health detriment, Nigeria

INTRODUCTION

The radioactivity periodic monitoring program of the territorial environment and foods is now a norm and a routine obligation in many countries of the world for her environmental and food safety, security and sustainability. After the Fukushima Daiichi nuclear power plant accident of March 12th 2011, occasioned by tsunami that released substantial amount of radioactive substances into Daiichi water and terrestrial environment, there have been public concern and anxiety of possible irradiation due to intake of radioactive contaminated food products from such environment *(Jibiri and Okusanya, 2008; Murakami, and Oki, 2012; Eun-Kyeong et al., 2016).* Similar routine monitoring and post-assessment of food products from Europe after the 1986 Chernobyl reactor accident have been reported in literatures *(Mlwilo et al., 2007*; *Jibiri and Okusanya, 2008).*

The complex pathway of radionuclides into man include; inhalation and external exposure to radiation, food consumed through the food chain *(UNSCEAR, 2000; Ononugbo et al., 2017).* Radioactivity contamination are observed in terrestrial environment and aquatic food chains, consequently they are transferred to man through the inhalation and intake of food *(Murakami, and Oki, 2012; Alrefae et al., 2014).* Beside the NORM naturally present in human due to it genetic make-up, elevation of radioactivity concentrations above normal levels are directly linked to the amount and type of food ingested *(FAO, 1987).* This linear relationship between food intake and radiological health hazard have raised international concern toward radioactivity implications from the consumption of food *(FAO, 1987; IAEA, 1989; Venturini and Sordi, 1999; Al-Masri et al., 2004; FSA, 2004; Mlwilo, et al., 2007; Chau and Michalec, 2009; Gharbi et al., 2010; Huff, 2011**;** WHO, 2011; Alrefae, et al., 2014; Ononugbo et al., 2017).* Ingested radionuclides accumulate in tissues and organs of the body, for example ^{238}U accumulates in human kidney and lungs, ^{232}Th concentrate in liver, skeleton tissue and lungs while ^{40}K accumulates in muscles *(Tawalbeh et a.l, 2012).* It have been reported that greater parts of the average annual effective dose due to natural sources is attributed to the intake of food *(UNSCEAR, 2000; Badran et al., 2003; Mlwilo et al., 2007; Jibiri and Okusanya, 2008; Ononugbo et al.,2017).* Excess accumulation of these radionuclides in any organ of the human body can impact negatively on the health of the individual, induces various forms of diseases and has been reported to contribute to the increase in mortality rate *(Agbalagba et al., 2016).*

Several research works have been published globally on radioactivity concentration in food products *(FAO, 1987; Yu et al., 1997; McDonald et al., 1999; Venturini and Sordi, 1999; Badran et al., 2003;Melquiades and Appoloni 2004; Al- Masri et al., 2004; FSA, 2004; Hernandez et al., 2004; Hosseini et al., 2006; Mlwilo, et al., 2007; Chau and Michalec, 2009; Shnthi el al., 2009; Gharbi et al., 2010; Zaid et al., 2010; WHO, 2011;Awudu et al., 2012; Giri et al., 2013; Al-Ghamdi, 2014; Alrefae, et al., 2014; Harb, 2015; Eun- kyeong et al., 2016; Al-Absi et al., 2019).* Nigeria is not left out in this vain, some research work on the evaluation of radionuclide content in staple foodstuffs and vegetable products have also been reported *(Olomo, 1990; Akinloye et al., 1999; Osibote et al., 1999; Farai, 1993; Maziya-Dixon et al., 2004; Arogunjo et al., 2005; Eyebiokin et al., 2005; Jibiri and Agomuo, 2007; Jibiri and Okusanya, 2008; Sowole, 2011; Njinga et al., 2015; Agbalagba el al., 2016; Ononugbo et al., 2017; Sowole and Olaniyi, 2018).* However, a thorough literatures examination reveals a pretty inadequate study on the radioactivity concentration of imported canned food products in Nigeria, with just two known studies carried out in the last ten years, with none examining the anthropogenic activities in those assessed foodstuffs *(Ali, 2008; Jibiri and Okusanya 2008; Alrefae et al., 2014; Agbalagba, et al., 2016).* The paucity of research studies and literatures on radioactivity content of imported processed canned food products into Nigeria lay credence to this current study to fill the gap and to satisfy the minimum national requirement for the establishment of a baseline value for radioactivity exposure rate for the public from the consumption of these categories of food products.

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This research work is therefore aimed at evaluating the anthropogenic (^{137}Cs) and NORMs (^{226}Ra, ^{232}Th, ^{40}K and ^{210}Pb) levels in the canned food products imported and widely consumed by Nigerian, compare the activity concentration in the three categories of canned foods: staple foodstuffs, beef products and seafood products. The study explores all known empirically justifiable inference on the risk or otherwise of consuming these canned food productions to Nigerians.

EXPERIMENTAL METHODS

Collection and Preparation of Samples

Canning is a method of preserving food from spoilage in which the food contents are processed and sealed hermetically and then sterilized by heat in an airtight container. The canned food product samples were collected from different local markets, stored and supermarkets in Nigeria. Researchers ensure that samples collected carried the regulatory Agency; "*National Agency for Food and Drug Administration and Control* (NAFDAC)" in Nigeria registration number and ensure that the products will not be expired in two months' time as at the time of collection. To ensure a widespread representation, 22 different canned food products were selected which covered 10 different brands: sweet corn, green peas, mushroom, vegetable, tomato, beans, beef, sausage, hotdog, and fish (tuna, sardine, geisha, and skipper) as presented in Table 1. These were further classified into three namely: staple foodstuffs, beef food products and seafood products.

Samples preparation for analysis follows standard practice as reported in literatures *(IAEA, 1989; Mlwilo et al., 2007; Alrefae, 2014)*. The preparation involved freeze-drying process that removed the moisture and reaching a constant weight while preserving vital contents *(Alrefae, 2014; Al-Absi et al., 2019)*. Samples were oven dried at a temperature range of 60 -75 ^{0}C for a period not least 24 hrs to attain constant weight. Samples were then homogenized and sieved using a 0.5 mm mesh sieve for similar sample matrix. The prepared samples were then powdered, packet into Marinelli beaker and sealed for a period not less than 28days to allow for equilibration before gamma analysis *(Mlwilo et al., 2007; Alrefae, 2014)*. The density of each sample was taken to correct for differences in the densities of the samples.

Table 1 Brand names and country of production of the different canned food products examined

Sample no.	Country of origin	Brand name	Type	Sample Net weight wet (g)
1.	Lebanon	Ailaghziah Beef Hot Dog	Hot Dog	380
2.	Thailand	Trio Golden sweet corn (whole kernels)	Sweet Corn	340
3.	China	Trio Green peas	Green peas	400
4.	Morocco	Milo sardine	Sardine	125
5.	Holland	Zwan Hotdog sausage	Sausage	400
6.	Lebanon	Golden county minced beef delight	Beef	400
7.	Italy	Montex luncheon beef	Beef	400
8.	South	Cattleman Corned beef	Beef	300
9.	Africa	Trio tuna chunks	Tuna	170

10.	Thailand	Trio mushroom (whole)	Mushroom	400
11.	China	Skipper (fish)	Fish	185
12.	Lebanon	Geisha (Mackerel in tomato sauce)	Mackerel	155
13.	China	Foodtown cream style golden sweet	Sweet corn	418
14.	USA	corn	Vegies	410
15.	South	Koo vegies	Baked beans	400
16.	Africa	Koo baked beans in tomato sauce	Beans	415
17.	South	Heinz beans	Tomato	410
18.	Africa	Braai relish tomato	Corn	350
19.	UK	Sweet kernel corn in vacuum	Tomato	410
20.	South	All gold Tomato puree	Vegetable	210
21.	Africa	Macedonia vegetable	Sausage	190
22.	Thailand	CSB sausage	Tuna Sausage	220
	South	White Tuna		
	Africa			
	Greece			
	N/A			
	N/A			

Gamma Spectroscopy

The detection and measurement of the radionuclides were performed with the aid of a lead-shielded (100mm) coaxial High Purity Germanium (HPGe) p-type (model: BE2020 and Serial number: b15168). The detector has energy resolution of 2.62 at 1.33MeV of ^{60}Co photopeak gamma-ray source with efficiency of 27.9% at similar energy peak. The obtained background spectra from unfilled container counted for 28800 seconds was used to determine the background activities of the radionuclides and their minimum detection limit. The energy and efficiency calibrations of the HpGe spectrometer system and analytical procedures adopted in this research work are well reported in literatures *(IAEA, 1989; Mlwilo et al., 2007; Alrefae, 2014).* Energy calibration of broad Energy Germanium detector was done with point sources of ^{241}Am, ^{137}Cs and ^{60}Co. The reference material used for the efficiency calibration was IAEA-414 with a cylindrical geometry of equal dimensions as the sample vessels.

Gamma Vision software was deployed for the spectra analysis, the samples ^{226}R activity levels were obtained using its progenies (^{214}Bi) of photopeak energy of 609.3 keV γ- lines. The ^{232}Th activity levels were determined using ^{208}TI emissions at 911 keV, similarly, ^{40}K activity levels were quantified by 1460 keV emissions. Finally, ^{137}Cs was likewise determined using the 662 keV $\gamma - ray$ peak, as one of the indicator isotopes for any potential environmental contamination due to release of artificial radionuclides. Self-attenuation correction factor for each sample in relation to the standard was determined using direct gamma transmission technique to correct for the efficiency of the standard used for the evaluation of the radioactivity level in the samples. The radioactivity content *C* (Bq kg^{-1}) was determined from the net peak

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area using the formula *(Jibiri and Okusanya, 2008; Arefae, et al., 2014).*

$$C = \frac{N_C}{\varepsilon \,.\, P_\gamma \,.\, M_S} \tag{1}$$

Where C represent the specific activity levels, N_c represents net gamma count rate (counts per second), ε represents the detector efficiency of the γ-ray, and M_s represents the sample mass in (kg), P_γ is the emission probability of the radionuclide.

The minimum detectable activity (MDA) of the measuring system describes the operational capability of the system without the influence of the sample, which is expressed as *(Kitto et al., 2006; Arefae, et al., 2014)*

$$MDA = \frac{2.71 + 4.66 S_b}{\varepsilon \, P_\gamma \, M_S} \tag{2}$$

where S_b= net background count standard error. The MDA values for the counting system were computed as; 0.33 for ^{226}Ra, 0.28 for ^{232}Th and 3.68 Bq kg^{-1} for ^{40}K.

RESULTS AND DISCUSSION

Results Presentation

The results of the measured activity concentration of the natural (^{226}Ra, ^{232}Th, ^{40}K and ^{210}Pb) and artificial (^{137}Cs) occurring radionuclides identified in the canned food samples investigation and their estimated errors are presented in Table 2.

Table 2 Specific activity concentration of the different canned food products

S/N	Staple Foodstuffs	Radioactivity Concentration (Bqkg^{-1})					
		Country	^{226}Ra	^{232}Th	^{40}K	^{210}Pb	^{137}Cs
1	Trio golden Sweet corn	Thailand	17 ± 3	7 ± 3	60 ± 17	6 ± 0	ND
2	Trio Green Peas	China	14 ± 3	10 ± 3	38 ± 11	8 ± 0	2 ± 0
3	Trio mushroom	China	20 ± 6	9 ± 3	37 ± 10	3 ± 0	1 ± 0
4	Macedoni a Vegetable	Greece	17 ± 6	21 ± 6	42 ± 12	6 ± 0	2 ± 0
5	Tomato puree	South Africa	16 ± 3	14 ± 5	90 ± 26	6 ± 1	2 ± 0
6	Sweet Kernel corn	Thailand	BDL	4 ± 1	40 ± 11	ND	ND
7	Braii relish tomato	South Africa	14 ± 5	14 ± 4	71 ± 20	ND	ND
8	KOO vegies	South Africa	16 ± 5	21 ± 6	38 ± 11	ND	ND
9	KOO baked beans	South Africa	BDL	5 ± 2	50 ± 14	ND	ND
10	Foodtown sweet corn	USA	22 ± 6	11 ± 4	45 ± 13	ND	ND
11	Heinz baked beans	UK	BDL	20 ± 7	56 ± 16	ND	ND
Total	**Activity Conc.**		**136 ± 40**	**136 ± 50**	**566 ± 166**	**29 ± 2**	**7 ± 2**
Mean	**Activity Conc.**		**12 ± 3**	**12 ± 4**	**51 ± 15**	**3 ± 0**	**1 ± 0**
	Beef Food Products	**Country**	**^{226}Ra**	**^{232}Th**	**^{40}K**	**^{210}Pb**	**^{137}Cs**
1	Zwan Hotdog sausage	Holland	12 ± 3	10 ± 4	47 ± 13	7 ± 0	1 ± 0
2	Minced beef delight	Lebanon	16 ± 3	13 ± 5	56 ± 16	0.2 ±0	BDL
3	Montex Luncheon beef	Italy	15 ± 5	7 ± 3	35 ± 10	BDL	1 ± 0
4	Ailaaghazah beef hotdog	Lebanon	1 ± 0	22 ± 5	65 ± 18	ND	ND
5	Cattleman corn beef	South Africa	21 ± 9	6 ± 2	72 ± 21	ND	ND
6	CSB sausage	N/A	21 ± 6	25 ± 7	27 ± 8	ND	ND
Total	**Activity Conc.**		**86 ± 28**	**85 ± 28**	**303 ± 88**	**7 ± 0**	**2 ± 0**
Mean	**Activity Conc.**		**14 ± 4**	**14 ± 4**	**50 ± 14**	**1 ± 0**	**0.3 ± 0**
	Seafood Products	**Country**	**^{226}Ra**	**^{232}Th**	**^{40}K**	**^{210}Pb**	**^{137}Cs**
1	Milo sardine	Morocco	21 ± 5	19 ± 5	55 ± 16	6 ± 1	ND
2	Mackerel Geisha	China	24 ± 6	8 ± 3	64 ± 18	BDL	ND
3	Skipper (fish)	Lebanon	28 ± 7	20 ± 6	50 ± 14	ND	ND
4	White Tuna	N/A	BDL	18 ± 5	81 ± 23	ND	ND

5	Trio Tuna chunks	Thailand	17 ± 8	17 ± 5	59 ± 17	ND	ND
Total	**Activity Conc.**		**90 ± 28**	**81 ± 27**	**308 ± 90**	**6 ± 1**	**NIL**
Mean	**Activity Conc.**		**18 ± 5**	**16 ± 5**	**62 ± 18**	**1 ± 0**	**NIL**

Table 3 Age groups (infants, children and adults) annual effective ingestion dose rate due to intake of natural radionuclides in canned foods

Radionuclides		**Annual Effective Dose(μSv)**		
Staple Foodstuffs		**Infants**	**Children**	**Adult**
^{40}K	Maximum	42.0	12.1	53.7
	Minimum	22.9	6.6	29.3
	Average	32.5	9.4	41.5
^{226}Ra	Maximum	182.9	179.3	166.5
	Minimum	70.0	96.8	90.0
	Average	112.9	138.1	128.3
^{232}Th	Maximum	87.5	68.9	50.7
	Minimum	27.4	31.4	23.1
	Average	60.1	50.2	36.9
	Accumulated Mean	205.5	197.6	206.7
Beef food Products				
^{40}K	Maximum	63.6	11.9	52.6
	Minimum	22.5	6.5	28.7
	Average	41.1	9.2	40.7
^{226}Ra	Maximum	172.9	215.0	199.7
	Minimum	67.8	107.7	100.0
	Average	135.4	161.4	149.9
^{232}Th	Maximum	67.1	77.0	56.7
	Minimum	32.9	37.7	27.8
	Average	50.0	57.4	42.3
	Accumulated mean	226.5	228.0	232.9
Seafood Products				
^{40}K	Maximum	50.2	14.5	64.3
	Minimum	27.5	7.9	35.1
	Average	38.9	11.2	49.9
^{226}Ra	Maximum	166.8	265.0	246.1
	Minimum	86.3	137.1	127.3
	Average	126.6	201.0	186.7
^{232}Th	Maximum	76.9	88.2	64.9
	Minimum	38.1	43.7	32.2
	Average	57.5	66.0	48.6
	Accumulated mean	223.1	278.2	285.2
UNSCEAR 2000 Recommendation		**200-800**	**200-800**	**200-800**

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Table: 4 Age groups (infants, children and adults) dose conversion factors for ^{226}Ra, ^{232}Th and ^{40}K *(ICRP, 1996)*

	Dose conversion factors(nSv/Bq)		
	^{40}K	^{226}Ra	^{232}Th
Infant(0−1y)	42	4700	4600
Children(1−12y)	13	800	290
Adult(>17y)	6.2	280	230

Table 5: Conversion factor (F) for different organs and tissues *(ICRP, 1996)*

Organ or Tissue	**Conversion Factor (F)**
Lungs	0.64
Ovaries	0.58
Bone marrow	0.69
Testes	0.82
Whole body	0.68
Kidney	0.62
Liver	0.46

Table 6: Calculated dose rate to vital organs and tissues of the body

Organs	Effective dose rate to organs (mSvy^{-1}) **Staple Foodstuffs**		
	Infants	Children	Adult
Lungs	0.2	0.1	0.1
Ovaries	0.1	0.1	0.1
Bone marrow	0.2	0.1	0.1
Testes	0.2	0.1	0.1
Kidneys	0.2	0.1	0.1
Liver	0.1	0.1	0.1
Whole body	0.2	0.1	0.1
Average values	**0.2**	**0.1**	**0.1**
Organs	Effective dose rate to organs (mSvy^{-1}) **Beef Products**		
	Infants	**Children**	**Adult**
Lungs	0.1	0.1	0.1
Ovaries	0.1	0.1	0.1
Bone marrow	0.2	0.1	0.1
Testes	0.2	0.1	0.2
Kidneys	0.1	0.1	0.1
Liver	**0.1**	**0.1**	**0.1**
Whole body	**0.2**	**0.1**	**0.1**
Organs	**Effective dose rate to organs (mSvy^{-1})** Seafood Products		
	Infants	**Children**	**Adult**
Lungs	0.1	0.1	0.1

Ovaries	0.1	0.1	0.1
Bone marrow	0.1	0.2	0.2
Testes	0.1	0.2	0.2
Kidneys	0.1	0.1	0.1
Liver	0.1	0.1	0.1
Whole body	0.1	0.2	0.2

Table 7: Results showing the committed effective dose

Age Group	Committed Effective Dose C_D ($mSvy^{-1}$)		
	Staple Foodstuffs	**Beef Products**	**Seafood Products**
Infant (0-1yr)	15.1	14.3	11.2
Children (7-12yrs)	9.9	11.4	13.9
Adult (>17yrs)	8.3	11.6	14.3

DISCUSSION OF RESULTS

Measured Radioactivity Levels

The obtained values of the measured radioactivity levels in the canned foodstuff imported into Nigeria are presented in Table 2. The results show that ^{226}Ra, ^{232}Th, ^{40}K, ^{210}Pb and ^{137}Cs have mean radioactivity levels of 12 ± 3 Bq kg^{-1}, 12 ± 4 Bq kg^{-1}, 51 ± 15 Bq kg^{-1}, 3 ± 0 Bq kg^{-1} and 1 ± 0 Bq kg^{-1} respectively for staple foodstuffs. In beef/poultry products, the mean activity levels for ^{226}Ra, ^{232}Th, ^{40}K, ^{210}Pb and ^{137}Cs are 14 ± 4 Bq kg^{-1}, 14 ± 4 Bq kg^{-1}, 50 ± 14 Bq kg^{-1}, 1 ± 0 Bq kg^{-1} and 0.3 ± 0 Bq kg^{-1} respectively, while 18 ± 5 Bq kg^{-1}, 16 ± 5 Bq kg^{-1} and 62 ± 18 Bq kg^{-1} for ^{226}Ra, ^{232}Th and ^{40}K respectively in seafood products. The ^{210}Pb radioactivity concentration of 6 ± 1 Bq kg^{-1} was only observed in Milo sardine while ^{137}Cs activity was not detected in any of the seafood products.

An assessment of the natural radioactivity content in the three categories of canned food products examined shows that radioactivity concentration is highest in the canned seafood products and lowest in the canned staple foodstuffs. However, mean value of the canned sea food products reported in this research work is below reported values in previous study on fresh water and marine fishes and crustacean, but exceeded the values reported in Hong Kong and Kuwait canned food *(Yu et al., 1997; Ademola and Ehiedu, 2010; Alrefae et al., 2014).* The mean radioactivity value obtained in the canned staple foodstuffs in this research work exceeded the values reported for food spices commonly used in Nigeria and selected fruits in some part of Nigeria. It also exceeded the reported activity concentration values in vegetables and fruits in Najaf in Iraq, Qena and Alexandria in Egypt, Elazig and Rize in Turkey, South and Southwest India and the activity concentration in vegetables consumed in Jordan *(Ibrahim et al., 2007; Shanthi et al., 2009; Shanthi et al., 2010; Korkmaz Gorrur et al., 2012;Adeniji et al., 2013; Cumhur and Mahmut, 2013; Harb, 2015; Abojassim, et al., 2014; Abojassim et al., 2016; Ononugbo et at., 2017; Sowole and Olaniyi, 2018; Al-Absi et al., 2019),.*

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Moreso, the radioactivity levels recorded in the investigated staple foodstuffs is below the reported value in Bangladesh vegetables, potato of Parana in Brazil and Syrian cereals *(Al-Masri et al., 2004; Scheibel and Appoloni, 2007; Islam et al., 2014)*. On the other hand, this obtained value for canned staple foodstuffs agreed with those values reported for staple foodstuffs in some part of Nigeria and Tanzannian *(Mlwilo et al., 2007; Jibiri and Okusanya, 2008)*.

The beef food products activity concentrations recorded in this ivestigation are within the range of values reported in dairy food products in Brazil *(Venturini and Sordi, 1999)*, The mean activity concentration value obtained in these imported canned beef products agreed with the reported values for imported milk products into Nigeria for ^{226}Ra and ^{232}Th but are well below the ^{40}K values reported in the dairy products *(Agbalagba, et al., 2016)*. The presence of the natural radionuclides in these can foods samples was expected. Specifically, detection of ^{40}K in all samples was anticipated due to its natural abundance as it was observed that the potassium samples have the highest activity concentration, because it is an important biological element circulated all over the human body and its content in man's tissue is under homeostatic regulation *(Mlwilo et al., 2007)*. The level of activity concentration of ^{210}Pb and ^{137}Cs in categories one and two of the canned food samples examined, may be attributed to man induced contamination of the sources of these food chain. These may also find their way into these canned food stuffs in the production processes and packaging *(Ram and Sarin, 2012; Paatero et al., 2015; Paatero, et al., 2017)*. The absence of ^{137}Cs in seafood products and some staple and beef food products may be attributed to good hygiene practices in the production processing and preservation of these food products *(IAEA, 1993; FDA, 1997; ICGFI, 1999; Hafsah and Kusdianti, 2014; Fadli et al., 2018)*.

Annual Effective Ingestion Dose to different Age Groups

The annual effective ingestion dose to individuals due to the intake of natural radionuclides (^{226}Ra, ^{233}Th and ^{40}K) in the selected canned foods were estimated using the formula from *(UNSCEAR 2000; Zaid et al., 2010)*

$$E_D = CIE \qquad (3)$$

where E_D is the annual effective ingestion dose (Sv y^{-1}), C is the specific activity concentration of radionuclides in the ingested food samples (Bq kg^{-1}) while I is the annual intake of canned food (kgy^{-1}) which depends on a given age and E is the ingested dose conversion factor for radionuclides (SvBq^{-1}), which varies with radioisotopes and the age of the individuals that consume the food products *(ICRP 1996)*.

The average consumption rate of food for infant, children and adult which represent the different age group of 110.0 kg y^{-1}, 15.0 kg y^{-1} and 0.3 kg y^{-1} for Infants and 140.0 kg y^{-1}, 7.7 kg y^{-1} and 2.3 kg y^{-1} for children and adult for canned staple foods, beef food and seafood products respectively *(FOS, 2006; Jibiri and Okusanya, 2008; Zaid et al., 2010)*. The results of the estimated annual effective ingestion dose to the different age group is presented in Table 3, while Table 4 is the conversion factors used for the three natural occurring radionuclides and the three age groups. The annual effective cumulative ingestion dose from the three natural radionuclides (^{226}Ra, ^{233}Th and ^{40}K) for infants, children and adults for staple food products are 205.5 μSvy^{-1}, 197.6 μSvy^{-1} and 206.7 μSvy^{-1} respectively, while for beef products it is 226.5 μSvy^{-1}, 228.0 μSvy^{-1} and 232.9 μSvy^{-1} respectively. For seafood products, the annual effective cumulative ingestion dose value for the three-age group examined are 223.1 μSvy^{-1}, 278.2 μSvy^{-1} and 285.2 μSvy^{-1} respectively. This values obtained are in agreement with the earlier reviewed values for imported and domestic foodstuffs in Nigeria, the values reported in selected fruits at Ijebu-Ode in southwest Nigeria and other parts of Nigeria, the reported values for some vegetables in Nigeria, the reported dose intake values from canned foodstuffs from Tanzanian and fruits commonly used in Najaf Governorate in Iraq, the values reported by Harb and they are within the range of ingestion dose values reported in canned seafood consumed in Kuwait and food products in some parts of the world *(Venturini and Sordi, 1999; Yu et al., 1997; Mlwilo, et al., 2007; Jibiri and Okusanya, 2008; Ademola and Ehiedu, 2010; Alrefae, et al., 2014; Harb, 2015; Abojassim et al., 2016; Agbalagba, et al., 2016; Sowole and Olaniyi, 2018)*. The highest cumulative total annual effective ingestion dose value of 285.2 μSvy^{-1} recorded for adults' seafood products is within the range of effective dose rate recommended by UNSCEAR for the general public *(ICRP, 1996)*.

Effective Dose Rate to different Body Organs and Tissues (D_{organ}) mSvy^{-1}:

The effective dose rate to organs can be calculated using the relation *(Agbalagba et al., 2016):*

$$Dorgan\ (mSvy^{-1}) = O\ x\ AEDE\ x\ F \qquad (4)$$

Where O = occupancy factor with a value of 0.8 and F= the conversion factor for the different organ dose (see Table 5). Table 6 present the obtained computed values of the effective dose rate assimilated by the various organs/tissues evaluated. In the staple foodstuffs, dose to infants' organs/tissues are highest in lungs, bone marrows, testes, kidney and whole body estimated to assimilate 0.2 mSv dose annual from the intake of these food products. The canned beef food products examined also show that the bone marrow, the testes and whole body of infants will receive the highest dose of 0.2 mSvy^{-1} due to intake of these food products, while the bone marrow, the testes and the whole body of the children and adult were estimated to assimilate the highest dose of 0.2 mSv each annually from the consumption of seafood products investigated. This shows that ^{226}Ra and ^{232}Th are the radionuclides most absorbed into the body organs *(Tawalbeh et al., 2012)*. These results obtained notwithstanding indicate that the estimated doses to different organs examined are below the international tolerable limits on dose to the body organs of 1.0mSv annually *(ICRP, 1996; UNSCEAR, 2000)*.

Committed Effective Dose (C_D)

The committed effective dose is a measure of the overall effective dose received over an average lifetime duration of 50 years resulting from ingestion of radionuclides. The three age groups of interest in this study are 0-1yr Infant, 7-12yrs children and >17yrs adults. These were identified and assessed for committed effective dose using

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the formula *(UNSCEAR, 2000; ICRP. 1991; Ibikunle et al., 2016):*

$$C_D = 50 \times E_D \quad (5)$$

The calculated value of the committed effective dose of the three age groups are using equation (5), show that the estimated values for infants and children are future base projections of the probable dose to be received by persons of these age bracket within a life span of 50years. The estimated values for infants are (15.1, 14.3 and 11.2) $mSvy^{-1}$ for canned staple foodstuffs, beef products and seafood products respectively, while for children it is 9.9, 11.4 and 13.9 $mSvy^{-1}$ respectively. The values obtained for children are 8.3 $mSvy^{-1}$, 11.6 $mSvy^{-1}$ and 14.3 $mSvy^{-1}$ for canned staple foodstuffs, beef food products and seafood products respectively. These values obtained reveal that radionuclide consumed from food product accumulate over time especially those with very long half-life with the adult age group accumulating more doses. It is therefore advisable for adult to reduce the quantities of intake of canned food products due to the projected health implications.

CONCLUSION

Naturally and artificial occurring radioactive materials in imported canned foods products in Nigerian markets has been examined using a High Purity Germanium detector. Artificial radionuclides (^{137}Cs) was found in some of the food samples while in others food samples they are below detectable level or not detected. The radioactivity concentrations of the sampled food products were observed to be dictated by the food category, country of origin and the sources of the food products. The activity concentrations of the natural radionuclides were found to be highest in seafood products compared to the staple foodstuffs and beef food products. However, the obtained results were established to be within the world-wide ranges of values reported in the reviewed scientific literatures and international regulatory bodies recommended permissible limits for ingestion of food by the public. The present of ^{137}Cs radionuclide in some of the staple foodstuffs and beef food products, cannot be associated with the irradiation of canned food but a trace of heavy metals content in the food items which requires further study while the present of ^{210}Pb is an indicated of heavy metal contamination of the source of food chain. It was observed from the annual effective dose computed, that the intake of the canned food samples by infants, children and adults at standard rates of their recommended intake per annum may not lead to any significant radiation dose to vital organs of the body above normal recommended value.

In general, the results obtained shows that the canned food products consumed in Nigeria are radiologically safe and may not pose any immediate and significant radiation health risk to consumers of these analyzed canned food products. However, the present of ^{137}Cs and ^{210}Pb in some analyzed food samples potent some degree of radiological contamination of these imported food products. It is therefore recommended that a precautionary measure be adopted in the consumption of these food items why future research be focus on increasing the number of samples for a more coverage and robust analysis.

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