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Long lived gamma emitters in Biscuit Samples consumed in Iraq

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ABSTRACT

Biscuit is important type of food that is widely consumed by baby in Iraq and other countries. This work measurers the natural radioactivity duo to long-lived gamma emitters in Children biscuit by gamma spectroscopy, and estimates radiation hazard indices which are the radium equivalent activity, the representative of gamma level index, the internal hazard index and annual effective dose in children. Ten samples were collected from the Iraqi market for different original countries. The average of specific activities for ^{226}Ra, ^{232}Th and ^{40}K were (9.390, 3.1213 and 214.969) Bq/kg respectively, but the average of the radium equivalent activity and the internal hazard index were 33.101 Bq/kg and 0.107 respectively. The total average of annual effective dose from consumption of adult, child and infant is estimated to be 0.655, 1.009 and 0.875 mSv respectively. The values of specific activity, radiation hazard indices and annual effective dose in all samples in this study are found lower than worldwide median value for all groups, therefore theses values are found to be safe.

Keywords: Radioactivity in food, Annual effective dose in food, Gamma Emitters in Biscuit and Iraq Markets.

1. Introduction

The primordial radionuclides have sufficiently longer half-lives, so that they survived since their creation and keep decaying to attain the stable state and producing ionizing radiation in various degrees (UNSCEAR, 1993). There are two potential primary exposure types connected with work involving radioisotopes: external and internal exposure to radiation. External hazards arise when radiation from a source external to the body penetrates the body and causes a dose of ionizing radiation. These exposures can be from gamma or x-rays, neutrons, alpha particles or beta particles; they are dependent upon both the type and energy of the radiation. Radioactive materials may be internally deposited in the body when an uptake occurs through one of the three routes of entry: inhalation, ingestion and skin contact (Tzortzis.M, et al 2003, UNSCEAR, 2000). Doses by ingestion (internal source) are due mainly to ^{40}K and to the ^{238}U and ^{232}Th series radionuclides are present in food and drinking water. Biscuits are one of the food products that received high acceptability among consumers. They are consumed by a wide range of populations, due to their variety in taste, long shelf life and relatively low cost (Vitali,D, et al., 2009). They are made from a combination of flour, shortening, leavening and milk or water. There are some studies in worldwide to investigate natural radionuclides in food consumed in different parts of the world (Al-Masri MS, et al., 2004, Hosseini T et al., 2006, Hosseini T et al., 2006, Jibiri NN and Okusanya AA, 2008 and T. Alrefae, T.N et al., 2012). The present study is the radioactive content of the biscuit consumed by infants, children and adults in Iraq. Therefore, the aim of the study are determine natural radionuclide activity concentrations in biscuit samples available in the Iraqi markets. The present study also aims to estimate radiation hazard indices and annual effective doses from consumption biscuit among various age groups.

2. Material and methods

2.1 Sample collection and preparation

The whole biscuit samples were purchased from different supermarket in Iraq and a wide-spread representation, 10 different biscuit that originated from 3 different countries were selected as shown in Table (1). The designated sample ID, Biscuit name and country origin. Since biscuit samples are not locally produced in Iraq, all samples were imported.

Table 1: Types and made of Biscuit samples in this study

Sample ID	Biscuit name	Country of Origin
B1	Petit Beurre var	Iran
B2	Baby Biscuit	
B3	Rana Pet whole	
B4	Minoo	
B5	Popel	
B6	Snakkers	
B7	Taky Crack	Turkey
B8	Petit	
B9	Luna	Saudi Arabia

After collection, each biscuit sample was kept in a plastic bag and labeled according to its name and country of origin. Then the samples were electronically crushed, using electric mill. In order to get homogeneity, the samples were sieved through of 0.8mm pore size diameter, and to keep them moisture-free they were put in an oven, in order to reach a constant weight. These samples were packed in a 1 L polyethylene plastic Marinelli beakers of constant volume, so that there is geometric homogeneity around the Detector , then the respective net weights were measured and recorded with a high sensitive digital weighing balance with a percent of ±0.01% . After that , the plastic Marinelli beakers were sealed with a PVC tape , and stored for about one month before counting , to allow secular equilibrium to be attained between ^{222}Rn and its parent ^{226}Ra in uranium chain (Nasim-Akhtar, et al., 2012) .

2.2 Gamma spectrometric analysis

The gamma spectrum from each samples was recorded using detector NaI(Tl) the volume of crystal is (“3 x 3”), a PC-based multichannel analyzer (4096 channel) and processed using the MAESTRO-32 software. The samples were placed on the detector and measured for a period of 18000 s. we obtained in our results from the gamma rays emitted by the progenies of ^{226}Ra and ^{232}Th which are in secular equilibrium with them, while ^{40}K was estimated directly by its gamma-line of 1460 keV. Hence the specific activity of ^{226}Ra were determined using the gamma-lines 1765 keV (^{214}Bi). The corresponding results of ^{232}Th were determined using the gamma-ray lines 2614 keV(^{208}Tl).

2.3 Radioactivity Determination

Count rates for each detected photopeak and activity for each of the detected nuclides are calculated. The specific activity (in Bq/kg), $\mathbf{A_{Ei}}$ of a nuclide **i** and for a peak at energy **E**, are given by (Harb, S. et al., 2008):

$$A_{Ei} = \frac{N_P}{t_c \times I_\gamma(E_\gamma) \times \varepsilon(E_\gamma) \times M} \quad \text{..........(1)}$$

Where N_P is the number of count in a given peak area corrected for background peaks of a peak at energy E_i, $\varepsilon(E_\gamma)$ the detection efficiency at energy E, t_c is the counting lifetime, $I_\gamma(E_\gamma)$ the number of gammas per disintegration of this nuclide for a transition at energy E, and M the mass in kg of the measured sample.

2.4 Calculation of radiological effects

There are two radiation indices were calculated, i.e., the radium equivalent activity($\mathbf{Ra_{eq}}$) and the internal hazard index ($\mathbf{H_{in}}$). In addition, the annual effective doses **D** in the different age groups were estimated.

2.4.1 Radium equivalent activity ($\mathbf{Ra_{eq}}$)

Distribution of ^{226}Ra, ^{232}Th and ^{40}K in environment is not uniform, so that with respect to exposure to radiation, the radioactivity has been defined in terms of radium equivalent activity (Ra_{eq}) in Bq/kg to compare the specific activity of materials containing different amounts of ^{226}Ra, ^{232}Th and ^{40}K (Beretka, I., Mathew, P.I.,1985 and NEA-OECD, 1979).

$$Ra_{eq} = A_{Ra} + 1.43A_{Th} + 0,077A_K \quad \text{...........(2)}$$

Where A_{Ra} , A_{Th} and A_K are specific activity concentration in Bq/kg of ^{226}Ra, ^{232}Th and ^{40}K, respectively. The index is useful to compare the specific activity of materials containing different concentrations of ^{226}Ra, ^{232}Th and ^{40}K.

2.4.2 Internal Hazard Index

The internal exposure to ^{222}Rn and its radioactive progeny is controlled by the interned hazard index (H_{in}) which is given by (Quindos, L.S., et al., 1987 and Cottens, E., 1990) :

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \quad \text{..........(3)}$$

For the safe use of a material in the construction of dwellings, index (H_{in}) should be less than unity and the maximum value of (H_{in}) to be less than unity (Iqbal, M. et al., 2000).

2.4.3 Annual effective dose for different age groups

The annual effective dose from consumption of breakfast cereal is calculated using the formula (UNSCEAR, 2000).

$$D\left(\frac{Sv}{y}\right) = A \times E \times I \quad \text{..........(4)}$$

Where **A** is the activity concentration for the radionuclide (Bq/kg), **E** is the dose conversion factor for the radionuclide (Sv/Bq), and **I** is the annual intake of sample (kg/y). The values of **E** are obtain in Table (2), in accordance with ICRP classifications (ICRP, 1996), namely adult, child (10 years old), and infant (1 year old), but values of **I** are taken to be 140, 90, and

45 kg/y for the age groups of adult, child, and infant, respectively, in accordance with UNSCEAR 2000.

Table 2: Dose conversion factors (nSv/Bq)

Age Groups	^{226}Ra	^{232}Th	^{40}K
Adults	280	230	6.2
Child (10 year old)	800	290	13
Infant (1 year old)	960	450	42

3. Result and Discussions

Table 3 represents the measured ranges and arithmetic mean specific activity concentration values ± standard deviation (S.D.) in Bq/kg for ^{226}Ra, ^{232}Th and ^{40}K in biscuit samples collected from different locations of Iraqi markets compared with the worldwide median values (WMVs) reported by UNSCEAR (2000). The ranges of specific activity of ^{226}Ra and ^{232}Th were found to be from (0.986±0.311) Bq/kg to (25.591±1.529) Bq/kg with an average (10.433) Bq/kg and from (1.084±0.175) Bq/kg to (16.651±0.681) Bq/kg with an average (4.584) Bq/kg, respectively, while the range of specific activity of ^{40}K was found to be from (156.243±4.153) Bq/kg to (350.226±6.694) Bq/kg with an average (214.969) Bq/kg. Table(4) shows the values of radium equivalent activity (Ra_{eq}) and internal hazard index (H_{in}) of ^{226}Ra, ^{232}Th and ^{40}K in biscuit samples. The internal hazard index was calculated for each sample using Eq. (3) which it was lie between 0.051 at sample B9 to 0.1791 at sample B10 with an average value of 0.107 respectively. Table 5 shows the results of the total annual effective dose in (mSv) for adult, child and infant which it is calculated using Eq. (4). The average of the total annual effective dose equivalent due to the specific activity levels of ^{226}Ra, ^{232}Th and ^{40}K for adult, child and infant (age groups) were found to be 0.655, 1.009 and 0.875 mSv respectively as shown in Figure (1).

The measured of the specific activity values for ^{226}Ra in biscuit samples were found to be the maximum detectable activities in sample B2 (Baby Biscuit , made in Iran) and the minimum detectable activities in sample B9 (Luna, made in Saudi Arabia), for ^{232}Th were found to be the maximum detectable activities in sample B4 (Minoo, made in Iran) and the minimum detectable activities in samples B5, B6 and B10 (Pope, Snakkers and Sesame biscuit, made in Iran and Saudi Arabia), while for ^{40}K were found to be the maximum detectable activities in sample B10 (Sesame Biscuit, Saudi Arabia) and the minimum detectable activities in sample B4 (Minoo, made in Iran). Therefore, The activity concentrations above for ^{226}Ra, ^{232}Th and ^{40}K are lower than the world median values (UNSCEAR, 2000). The estimated radium equivalent activity vary from 18.486 Bq/kg at sample B9 to 55.229 Bq/kg at sample B10 with an average value of 33.097 Bq/kg were lower than the maximum permissible level of 370 Bq/kg recommended by UNSCEAR(2000). This indicates that internal hazard index in biscuit samples was lower than the permissible limits of 1 recommended by UNSCEAR(2000). It is obtain from Table 5 and Figure 1 that total annual effective dose from consumption of biscuit samples for child is the largest contributor to the total annual effective dose from consumption for adult and infant. This increases in child duo to the dose conversion factor for the radionuclide and the annual intake of sample. This indicates that the annual effective dose in all biscuit samples were lower than the permissible limits of 1mSv recommended by ICRP(1996).

Table 3: Specific activity of the biscuit samples

Sample ID	Specific activity in Bq/kgm		
	^{226}Ra	^{232}Th	^{40}K
B1	10.528±1.043	4.205±0.350	164.058±4.355
B2	25.591±1.529	1.887±0.221	201.460±4.541
B3	8.589±0.891	4.024±0.324	222.822±4.801
B4	0.986±0.312	16.651±0.681	156.243±4.154
B5	11.252±1.131	BDL	256.122±5.709
B6	7.297±0.787	BDL	200.823±4.369
B7	7.160±0.849	1.084±0.176	169.662±4.378
B8	2.734±0.558	1.869±0.246	207.522±5.146
B9	BDL	1.489±0.197	220.7529±4.779
B10	19.764±1.503	BDL	350.226±6.694
Average	**10.433**	**4.458**	**214.969**
Worldwide Median Value (UNSCEAR, 2000)	**35**	**30**	**400**

BDL = Below detection limit

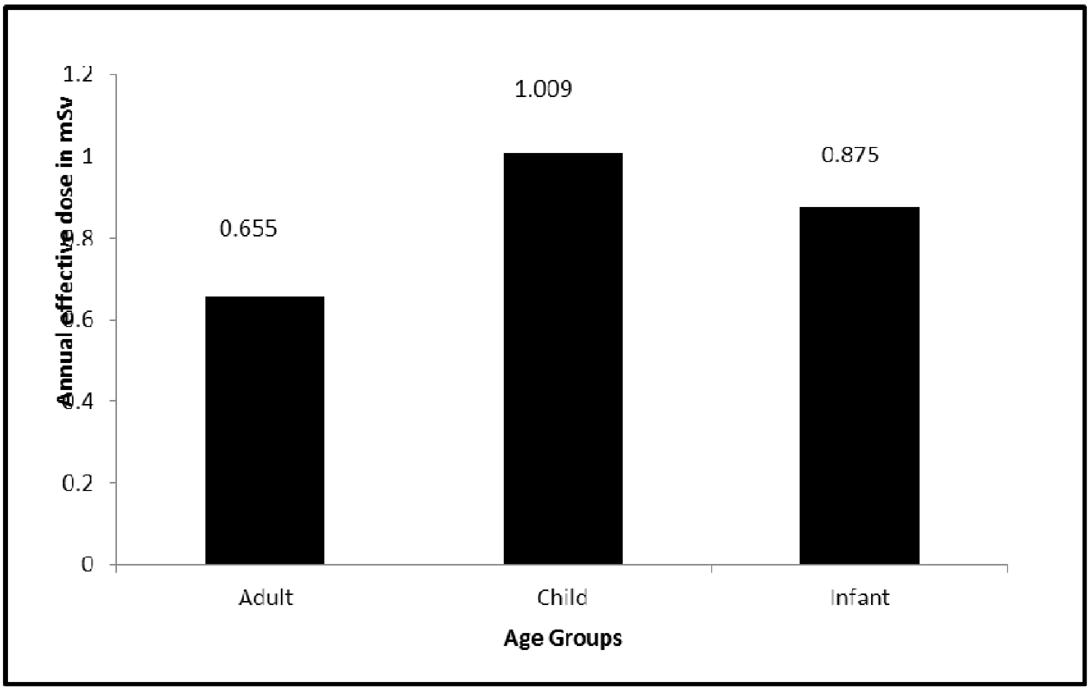

Figure 1: The average of annual effective doses for adult, child and infant (age groups)

Table 4: Radiation hazard indices from consumption of biscuit samples

Sample ID	Radium equivalent (Bq/kg)	Internal hazard
B1	31.893	0.107
B2	53.995	0.187
B3	33.464	0.108
B4	30.092	0.102
B5	35.812	0.114
B6	25.898	0.081
B7	24.387	0.078
B8	21.758	0.065
B9	18.487	0.051
B10	55.229	0.179
Average	**33.097**	**0.107**
Worldwide Median Value (UNSCEAR, 2000)	**< 370**	**≤ 1**

Table 5: Total of annual effective doses from consumption of biscuit samples for age groups

Sample ID	Total of annual effective dose in (mSv)		
	Adult	Child	Infant
B1	0.691	1.059	0.850
B2	1.239	2.128	1.525
B3	0.659	0.984	0.874
B4	0.710	0.688	0.675
B5	0.663	1.109	0.970
B6	0.460	0.760	0.695
B7	0.463	0.742	0.652
B8	0.347	0.488	0.548
B9	0.239	0.297	0.447
B10	1.079	1.833	1.516
Average	**0.655**	**1.009**	**0.875**

4. Conclusions

The study estimated specific activity of radionuclides ^{226}Ra, ^{232}Th and ^{40}K using gamma ray spectroscope in different types of biscuit that are regularly consumed by all groups age in Iraq. Specific activity concentrations of these radionuclides in samples were lower than as reported by UNSCEAR. So , we can deduce that the radionuclides level in the studied samples of biscuit for adult, child and infant is can be normally consumed. Also the radiation hazard indices values obtained when compared with the world permissible values were found to be below the standards limit which due to be radiologically hazard safe. Total averages annual effective dose due to the ingestion of all three natural radionuclides for different age groups of adult, child and infant are found to be within the average annual ingestion radiation dose due to natural sources .Therefore, total average annual effective dose was far below the WHO recommended limit and ICRP for radiological safety .

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