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NATURAL RADIOACTIVITY IN CERELAC BABY FOOD SAMPLES COMMONLY USED IN IRAQ

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Abstract

Radioactivity in Food can be polluted with many types of radioactive materials due to natural and a nuclear emergency. The aims of this work are to govern the specific activity ^{238}U, ^{232}Th and ^{40}Kas well as calculate the annual effective dose due to the ingestion of cerelac baby food that available in Iraqi markets. Samples were collected from local market in Najaf from different countries of origin. The levels of ^{238}U, ^{232}Th, and ^{40}K were determined using gamma ray spectrometer. The results show that, the average specific activities for ^{238}U, ^{232}Th, and ^{40}Kwere 8.49±2.18, 4.50±0.80and 223.85±29.22Bq/kg, respectively. However, the average value of radium equivalent activity and internal hazard index were 32.16±2.77Bq/kg and 0.109±0.012 respectively.whereas the total average annual effective dosecaused by ^{238}U, ^{232}Th, and ^{40}Kfor children is estimated to be 0.571±0.05mSvy. The values found for specific activity and the annual effective dose in all samples of cerelac baby foodwere lower than worldwide median values for children; therefore, these values are found to be safe.

Key words : Natural Radioactivity, cerelac baby food, Gamma spectrometer and Iraqi food.

Introduction

Radioactive material is found throughout nature. It exists naturally in the soil, water and vegetation. However, the primordial radionuclides have radioactive decay half-lives ranging around (4-5 billion years) *i.e.* equal to Earth's age. Moreover, primordial radionuclides with their radioactive decay are considered as important radioactive sources in the earth, which paly an important factor that control Earth's processes. Certainly, the primordial radionuclides, specially the potassium isotope (^{40}K) is considered a significant constituent of a fertile process for soil and is crucialnutrient for plant growth processas well as in the human diet (Raymond, 1994). ^{40}K primordial radionuclide is considered the most widespread primordial radionuclide on the earth, because it forms around 3×10^{-3}%. An additional natural primary radionuclides is ^{232}Th, of half-life $T_{½} = 1.39\times10^{10}$ years which is characterized with steadily disintegrated by emit α decay into a number of radionuclides that called thorium decay chain. However, ^{238}U is accounted as the most important natural radionuclides in the Earth's crust with a half-life $T_{½} = 4.49\times10^{9}$ years. Uranium have the ability to enter the body by the inhalation or swallowed process, or else under rare circumstances it canarrivethe internal organismsthrough cuts in the skin. The Uranium which is being outside the body of human and its product (alpha particles) have not penetrate the skin, therefore, it consider much less dangerous compare with that inhaled or swallowed (USEPARPP, 2015). The surface of food is contaminated with radioactivematerials by deposit on it from air or falling rain water (The Government of the Hong Kong Special Administrative, 2013). The plants have the ability to absorb Radionuclides, which be in soil and these particles of Radionuclides will transfer through food chains. Moreover, these plants will consumed for human as food. Many have been published works on contaminated food with radioactive materials in the environment and its mechanism to transfer to plants,

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animals and human population. However, the ingestion process of natural radionuclides limited by the consumption rate of food, water and the radionuclide concentrations. Naturally occurring radio nuclides enter the human body mainly by ingestion of primordial radio nuclides and their progeny ^{40}K, ^{238}U and ^{232}Th series. The ingested process of radio nuclides may be occurs in particular parts of the human body, for instance^{40}K nuclides are accumulated in the muscles, ^{238}U is in humanlungs andkidney and ^{232}Thnuclides are accumulated in skeleton tissue and liver (Adeniji *et al*, 2013). There are some studies prove the food have natural radionuclides which consumed in many parts of world (Harb, 2015; Islam *et al*, 2014; Cumhur and Mahmut, 2013; Filiz *et al*, 2012; Gharib and Ghaeib, 2010; Shanthi *et al*, 2010, 2009; Ibrahim *et al*, 2007; Chibowski, 2000). The present study in literate are which aimed to radioactive content of the cerelac baby food that consumed by children in Iraq and other countries. As well as this study aimed to evaluate the internal hazard index, in addition to radium equivalent activity and annual effective doses from consumption samples under study.

Materials and Methods

Sample collection and preparation

The present study focuses on the ingestion of cerelac baby foodconsumed by children in Iraqi. Ten samples were collected in study area are presented in table 1.

Table 1 : Shows the food categories of vegetables samples in this study.

No.	Sample name	Sample code	Country
1	Ninolac	C1	Belgium
2	Schoice'mother	C2	Oman
3	Nestal cerelac	C3	Vietnam
4	Ulker baby	C4	Turkey
5	Ridielac	C5	Switzerland
6	Nastle cerelac	C6	Spain
7	Nactalia	C7	France

The samples is placed in a plastic container and labeled by name and country of origin. Then the samples were crushed electronically, using electric mill for homogeneity, the samples were sieved (0.8-mm-pore-size sieve); they were kept moisture-free in an oven, so that reach a constant weight. 1-literplastic Marinelli beakers made by polyethylene were used for packing the samples for attaining a geometric homogeneity around the detector, this step followed by measuring the respective net weights with a weighing balance of high sensitive (60.01%). Next, PVC tape is used to tap the Marinelli beakers and stored for around 1 month before counting process in order to allow a secular equilibrium to be achieved between ^{222}Rn and its parent ^{226}Ra in uranium chain.

NaI(TI) Gamma Ray Spectroscopy

Gamma ray spectroscopy system and scintillation detector NaI(TI) from ORTEC has an active area of "3×3" inches, energy resolution 7.9% and Efficiency of 4.6% at the 662 KeV. Efficiency calibration and energy calibration of gamma spectrometer were accomplishe dusing (^{60}Co,^{137}Cs, ^{22}Na and ^{54}Mn) form the Nuclear Laboratory in Physics Department, which is contain seven gamma-ray emitters ranged from 511 KeV to 2500 KeV. The lowest level of detection (LLD) for ^{238}U, ^{232}Th and ^{40}K were 3.17 Bq/kg, 1.2 Bq/kg and 11.54 Bq/kg, respectively. The standard source has a geometric shape matching to the geometrical of sample shape that is putted over the detector with the same distance, which separate the sample and the detector. However, the radioactive background will reduce for different radiations via shield of two layers, the first layer is fabricated from stainless steel of width (10 mm) followed with another layer of lead (30 mm).

In this work, the peak areas at 1460 KeV enable us to calculate the specific activity of ^{40}K, whereas specific activity of ^{238}U and ^{232}Th were determined by considering a secular equilibrium with their decay products. Moreover, gamma transition lines give us the ability to measure specific activity of radioisotope, in this study, the line transitions of ^{214}Bi (1765 KeV) and ^{208}Tl (2614 KeV) were used to specific activities of ^{238}U-series and ^{232}Th-series respectively with counting time around 18000 sec.

Data Analysis & Mathematical Formula

Count rates for each detected photo-peak and activity for each detected nuclides were calculated. In order to calculate the specific activity in (Bq/kg), following equation is used for that purpose (Harb *et al*, 2008):

$$A_{rf}\left(\frac{Bq}{kg}\right) = \frac{N - N_0}{I_\gamma \varepsilon m t} \tag{1}$$

where, C_r represents activity concentration of the sample's radionuclide and given in Bq kg^{-1}, N represents the whole counts of a specific peak for a sample, N_o is the background of the given peak, I_γ represents the number of gamma photons for each disintegration, ε shows the detector efficiency at the specific γ-ray energy, m is the mass in kg of the measured sample and t is the counting time for the sample.

In case of existence many peaks, the method for calculating energy analysis variety for a nuclide is being by taking the average of the peaks activities and the product will be the weighted average nuclide activity. Established on the calculatedpeaks of γ-ray, which emitted by specific radionuclides in the ^{238}U , ^{232}Th decay series and ^{40}K (Harb, 2015).

The radium equivalent activity is considered as the greatest commonly used radiation hazard index (Ra_{eq}). This factor is the weighted sum of activities of the three radionuclides, which are the specific activity of ^{238}U (^{226}Ra), ^{232}Th and ^{40}K, Ra_{eq} activity is given by Ali *et al.* (2014):

$$R_{eq}\left(\frac{Bq}{kg}\right) = A_{R\alpha} + 1.43A_{Th} + 0.077_{AK} \qquad (2)$$

Internal hazard index

The internal index (H_{in}) was also determined using the following equations (Ali *et al*, 2015):

$$H_{in} = \frac{A_{R\alpha}}{180} + \frac{A_{Th}}{259} + \frac{A_K}{4810} .... \qquad (3)$$

The International Commission of Radiological Protection agency developed a special factor named as annual effective dose term which represents the radiation that generated by the process of ingestion of foods which performed by the metabolic model (ICRP, 1996). The annual effective dose (D_{rf}) factor, which produce by radionuclide (r) in a foodstuff (f) is measured by equation (Harb, 2015; Filiz *et al*, 2012; Nasreddine *et al*, 2008):

$$D_{rf}\left(\frac{Sv}{y}\right) = (C_r A_{rf}) \times R_f \qquad (4)$$

D_{rf} represents the annual effective dose which produce by ingestion process for the radionuclide with units of (r, Sv/y), C_r represents the adaptation factor of the effective dose term that produce by ingestion process for the nuclide (r) (*i.e.* the dose given in Sv units produce by the exposure to source of radiation activity of concentration (1 Bq) of nuclide (r) via oral ingestion) table (2), A_{rf} represents the activity concentration of radionuclides which produce by the nuclide (r) inside the ingested food with units of (f, Bq/kg) and R shows the rate of consumption process for the food with units of (f, kg/y) (Cumhur and Mhamut, 2013; Filiz *et al*, 2012; IAEA, 1996).

Table 2 : Represents the dose convection factors C_r for different Radionuclides in Sv Bq^{-1} (ICRP, 1996).

Radionuclides	Dose convection factor
^{238}U (^{226}Ra)	2.25×10^{-7}
^{232}Th	3.69×10^{-7}
^{40}K	5.9×10^{-9}

Results and Discussion

The levels of activity concentrations of radionuclides in the food samples for natural radionuclides like ^{238}U, ^{232}Th and ^{40}K, are specified in table 3.

The highest concentrations levels showed in table 3 match to the levels of naturally occurring radionuclide ^{40}K. The highest concentration levels of 332.58±5.654 Bq kg^{-1} was calculated in sample C7 (Nactalia, made in France), while the lowest concentration: 128.84±3.52Bq kg^{-1} in sample C1 (Ninolac, made in Belgium) with an average 223.85±29.22Bq kg^{-1}. Sample C5 (Ridielac, made in Switzerland) was contained the highest concentration of ^{238}U, at 16.08±1.22Bqkg^{-1}, while the lowest concentration, at 1.44±0.36Bq kg^{-1}, was measured in sample C7(Nactalia, made in France) with an average 8.49±2.18Bq kg^{-1}. The highest concentration of ^{232}Th 7.85±0.54Bq kg^{-1} was measured in C1 (Ninolac, made in Belgium). The lowest concentration of ^{232}Th 1.07±0.20 Bq kg^{-1} was measured in C5 (Ridielac, made in Switzerland) with an average 4.50±0.80Bq kg^{-1}.

From table 4,, it is found that the radium equivalent levels ranging from (23.306 to 41.14 Bq/kg), while the highest level was in sample (C6) and lower level was in sample (C1) with average value around (32.16±2.77 Bq/kg). The internal hazard index of samples in present study was registeredthe maximum levels (0.153) for sample (C5) and the minimum values was (0.069) in sample (C1) with an average (0.109±0.012), as shown in table 4.

The total annual effective dose due to ^{238}U, ^{232}Th and ^{40}K as shown in table 5 were ranged from (0.377 to 0.726) mSv/y, with average 0.571±0.05. Whereas, the data have revealed that sample (C7) records highest total annual effective dose, which is made in France, and total lower annual effective dose records insample (C1) which is made in Belgium.

From data obtained, the specific activity of ^{40}K have been calculated for many samples of food, ^{40}K (Bq/kg) were higher than specific activity of ^{238}U and ^{232}Th (fig. 1). The high level of activity concentration of Potassium registered for all sample differ according to the geographical position for the soil of cultivation in addition to some plants also may be because of the fact that, the activity concentrations for soil is different geographically for each place as well as some plants have a different ability to absorb elements.Whereas, the values of specific activity of ^{40}K, ^{214}Bi (^{238}U series) and ^{208}Tl (^{232}Th series)

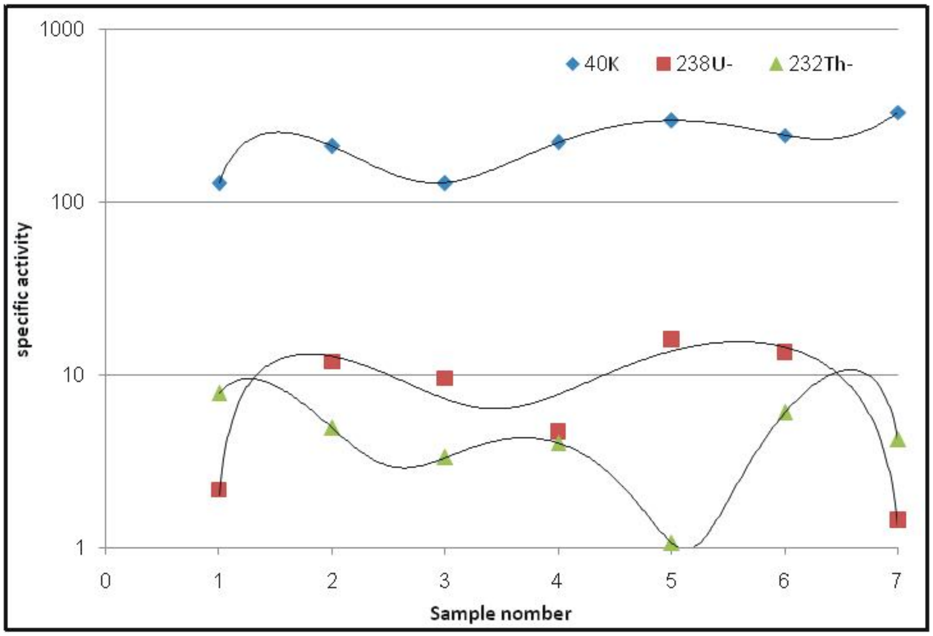

Fig. 1 : Compare between specific activity for ^{238}U, ^{232}Th and ^{40}K.

Table 3 : shows the specific activity levels for ^{238}U, ^{232}Th, and ^{40}K in samples under study.

No.	Code of samples	Specific activity (Bq/kg)					
		^{40}K	±S.D	^{238}U	±S.D	^{232}Th	±S.D
1	C1	128.84	3.52	2.16	0.44	7.85	0.54
2	C2	210.76	4.50	11.90	1.04	4.93	0.43
3	C3	129.61	3.53	9.56	0.93	3.33	0.35
4	C4	222.20	4.62	4.69	0.65	4.04	0.39
5	C5	298.20	5.40	16.08	1.22	1.07	0.20
6	C6	244.80	4.85	13.61	1.11	6.07	0.47
7	C7	332.58	5.65	1.44	0.36	4.22	0.40
Average±S.D		223.85±29.22		8.49±2.18		4.50±0.80	
Worldwidemedian value [a]		35		30		400	

* [a]Data from UNSCEAR (2000).

Table 4 : shows the results of Radium equivalent activity with internal hazard index.

No.	Sample code	Ra_{eq} (Bq/kg)	H_{in}
1	C1	23.30	0.069
2	C2	35.17	0.127
3	C3	24.30	0.091
4	C4	27.57	0.087
5	C5	40.57	0.153
6	C6	41.14	0.148
7	C7	33.08	0.093
Average±S.D		32.16±2.77	0.109±0.012
World wide median value		370	≤1

in samples of cerelac baby foodare found in safe range because it were lower than the world average levels which allowed maximum values 400, 30 and 32 Bq/kg

Table 5 : Annual effective dose in all samples at children age.

No.	Code of samples	Annual effective dose (mSv/y)			
		^{40}K	^{238}U	^{232}Th	Total
1	C1	0.255	0.017	0.104	0.377
2	C2	0.417	0.096	0.065	0.579
3	C3	0.257	0.077	0.044	0.378
4	C4	0.440	0.038	0.054	0.532
5	C5	0.590	0.130	0.014	0.735
6	C6	0.485	0.110	0.081	0.676
7	C7	0.659	0.012	0.056	0.726
Average ± S.D					0.571±0.05

(UNSCEAR, 2000), respectively. This can be clarified by what soil ails from abundance of this isotope concentration.

From table 4, it can be seen that the Ra_{eq} levels for all tobacco samples remained lower than the recommended levels 370 Bq/kg by Abojassim *et al*, 2016). Also, from table 4, however, the levels for all these operators which studied for all samples lies in the safety limit which recommended by UNSCEAR (2000). As seen in table 5, total annual effective dose from cerelac baby foodconsumption by children was lower than the permissible limit of 1 m Sv which recommended by the International Commission on Radiological Protection (ICRP, 1996).

Conclusion

Specific activity of (^{238}U, ^{232}Th and ^{40}K), Ra_{eq}, Hin and annual effective dose in samples of cerelac baby food consumption by children are produced and frequently consumed in Iraq were determined in this study. The specific activity levels of these radionuclides for all samples under study were under the levels of those which reported by UNSCEAR. Also, it is found that annual effective doses which caused by the ingestion of all three natural radionuclides by children below the limit that recommended by the International Commission on Radiological Protection for radiological safety.

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