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Measurement of natural radioactivity in some imported foodstuffs

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Abstract :

In this study, the specific activity concentrations of ten samples of some imported food items (flour, corn, lentils, beans, rice, pasta, okra, mung beans, chickpeas, and Indomie) obtained from different origins were measured using the HPGe detector. From the measurement, it was observed that the average values of the specific activity concentrations (238U, 232Th, 40K) were equal to (1.220±3.8 Bq/kg), (1.305±1.7 Bq/kg), (1.546±0.8 Bq/kg) respectively. The results were lower than the global recommended values of (UNSCEAR,2000). The radiation hazard indicators [Raeq, Dɣ, (AED) in, (AED) out, Hin, Hex and Iɣ] were also studied and all the results obtained were lower than their corresponding average values reported by (UNSCEAR, 2000). Therefore, the results of the present work showed that all the samples of imported food studied are safe.

Keywords : (HPGe) detector , foodstuffs samples, hazard indices , radioactivity.

قياس النشاط الاشعاعي الطبيعي في بعض المواد الغذائية المستوردة

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مستخلص:

في هذا البحث، تم إجراء قياس تركيزات النشاط النوعي لعشرة عينات لبعض المواد الغذائية المستوردة (طحين ، ذرة ، عدس ، فاصوليا ، رز ، معكرونة ، بامية ، ماش ، حمص ، اندومي) تم الحصول عليها من مناشئ مختلفة باستخدام كاشف (HPGe). ومن القياس، لوحظ أن متوسط قيم تركيزات النشاط النوعي (^{40}K, ^{232}Th ,^{238}U) كانت مساوية (Bq/kg 1.220±3.8) (1.305±1.7Bq/kg) ، (Bq/kg 1.546±0.8) على التوالي ، وكانت النتائج أقل من القيم العالمية الموصى بها من (UNSCEAR، 2000). كما تمت دراسة مؤشرات الخطر الإشعاعي [I_{γ}, H_{ex}, H_{in}, $(AED)_{out}$, $(AED)_{in}$, D_{γ}, Ra_{eq}] وكانت جميع النتائج التي تم الحصول عليها أقل من متوسط قيمها المقابلة التي أوردتها (UNSCEAR، 2000) وبالتالي، أظهرت نتائج العمل الحالي أن جميع عينات المواد الغذائية المستوردة المدروسة آمنة .

الكلمات الافتتاحية : كاشف الجرمانيوم ، نماذج غذائية ، دليل الخطورة ، نشاط اشعاعي.

Introduction

After the Chernobyl and Fukushima nuclear accidents, it became evident, that accurate and rapid method is necessary for the routine determination of artificial radionuclide content in foodstuff [1]. Radionuclides are existed naturally in our environment, including our bodies, animals, food, and water. exposure to radiation comes from space, in addition to the naturally-occurring radioactive materials found in soil, water, and air. The radionuclides may detect in food and water and their concentrations vary relative to several factors like local geology, weather, and agricultural methods. Radioactivity can contaminate food after it has been discharged into the environment from industries. Whether artificial radionuclides enter the food chain in the same way as non-radioactive material. The amount of injury in health human depends on the kind of radionuclides and the time of exposure to them [2].

Materials and Method

Several samples of different types of foodstuffs were collected from Iraq markets with mass more than 1kg. The choice of these samples, ten samples of different foodstuffs imported from different countries and different companies, which were available in Iraqi market, were chosen and collected. All local samples were cleaned and dried before grinding. After the samples are collected, they are crushed with the grinder to get a non-homogeneous powder of the samples, after that the powder will be sifting through sieve an of (630µm) mesh size. After that, the samples are fully mobilized in the Marinelli beakers and sealed, Marinelli beaker was saved for 30 days before the examination in order to reach the equilibrium of secular type for both ^{238}U and ^{232}Th radionuclides with their products, The detector in the using (HPGE) spectroscopy has a model (GEM20P4&CFG-PV4), it's manufactured in the USA, with an efficiency of 40%, operates at voltages of (+4000V), and it is a high purity N-type semiconductor detector with crystal dimension (3"x3"). This detector is shown in figure (1).

Figure (1): Gamma spectrometric system.

Determination of some gamma Radiation Parameters

1. Activity Concentration

$$A = \frac{NET}{\varepsilon * I_\gamma * m * t} \dots\dots\dots\dots (1)$$

Where:

A: Activity Concentration, m: mass of sample , I_γ : energy efficiency , t: time measurement (3600 s).

2- Radium Equivalent

Radium equivalent calculation from the following equation [4] :

$$Ra_{eq}(Bq/kg) = A_U + 1 \cdot 43A_{Th} + 0 \cdot 077\, A_K \dots\dots\dots (2)$$

Where A_U, A_{Th}, A_k activity concentration of a series of Uranium and a series of Thorium and Potassium, respectively, in the equation (2) Assume that (10 Bq/kg) of Uranium and (7 Bq/kg) of Thorium and (130 Bq/kg) of Potassium produces an equal dose of radiation [5].

3- Absorbed Dose Rate

The total rate of the absorbed dose in the air is calculated in terms of the concentrations of (^{238}U, ^{232}Th and ^{40}K), through the following equation [5,6]:

$$D(nGyh^{-1}) = 0 \cdot 429A_U + 0 \cdot 666A_{Th} + 0 \cdot 042A_K \dots\dots\dots\dots (3)$$

4- The Annual Effective Dose

To calculation, the annual effective dose must take the following consideration, first: conversion factor of absorbed dose to effective dose, second: Internal occupation factor. Use the factor 0.7Sv as a conversion factor from absorbed dose in the air to the annual effective received by the adult dose and use 0.8 as an internal occupation (which is the ratio of time spent at home) and 0.2 is the ratio of time spent abroad, and this data found that the annual effective dose calculated as follows [7] :

$$E_{in}\, dose(\mu Svy^{-1}) = D(nGyh^{-1} * 8760hy^{-1} * 0\cdot 2 * 0\cdot 7(svGy^{-1}) \ldots (4)$$

$$E_{out}\left(\frac{mSv}{y}\right) = \mathrm{D}\left(\mathrm{nGy.h}^{-1}\right) \times 10^{-6} \times 8760\left(\frac{h}{y}\right) \times 0.20 \times 0.7(SvGy^{-1}) \ldots \ldots (5)$$

where the 8760 refers to the number of hours a year. The global average annual effective dose is 0.48 mSv.

5- External Hazard Index

The external guide is a hazard assessment of the risk of natural gamma radiation, is calculated from the following equation [8] .

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \ldots \ldots \ldots \ldots \ldots (6)$$

Where this factor must be less than one , if equal to or greater than one indicates the presence of radiation risk.

Activity Concentration Index (I_{γ})

The activity index (I_{γ}) for foodstuffs samples was calculated by using the following equation [8]:

$$I_{\gamma} = \frac{A_U}{300} + \frac{A_{Th}}{200} + \frac{A_K}{3000} \ldots \ldots \ldots \ldots (7)$$

6- Internal Hazard Index

The internal exposure is caused by the inhalation of radon gas and daughters which can be expressed in terms of the internal hazard index and calculates by the following equation [9] :

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \leq 1 \ldots \ldots \ldots \ldots (8)$$

And this factor must be less than the one to be within the allowable universally border.

Results and Conclusions

The results of the present work was summarized in Table (1) it can be noticed that:

The highest value of specific activity of (^{238}U) was found in Cicer sample which was equal to (1.950 Bq/kg), while the lowest value of specific activity of (^{238}U) was found in Rice sample which was equal to (0.460 Bq/kg) ,with an average value of (1.220±3.8 Bq/kg). The present results have shown that values of specific activity for (^{238}U) in all samples studied were less than the recommended value of (35 Bq/kg) [10].

The highest value of specific activity of (^{232}Th) was found in Beans sample which was equal to (1.880 Bq/kg), while the lowest value of specific activity of (^{232}Th) was found in Lentil sample which was equal to (0.460 Bq/kg), with an average value of (1.305±1.7 Bq/kg). The present results have shown that values of specific activity for (^{232}Th) in all samples studied were less than the recommended value of (30 Bq/kg) [10] .

The highest value of specific activity of (^{40}K) was found in Cicer sample which was equal to (1.920 Bq/kg), while the lowest value of specific activity of (^{40}K) was found in Beans sample which was equal to (1.220 Bq/kg), with an average value of (1.546±0.8 Bq/kg). The present results have shown that values of specific activity for (^{40}K) in all samples studied were less than the recommended value of (400 Bq/kg) [10] .

The highest value of radium equivalent activity was found Cicer sample which was equal to (4.500 Bq/kg), while the lowest value of radium equivalent activity was found in Rice sample which was equal to (1.648 Bq/kg) ,with an average value of (3.205±0.8 Bq/kg). The present results have shown that values of radium equivalent activity in all samples studied were less than the recommended value of (370 Bq/kg). [10] .

The highest value of absorbed dose rate (D_γ) was found in Cicer sample which was equal to (1.996 nGy/h), while the lowest value of absorbed gamma dose rate was found in Rice sample which was equal to (0.730

nGy/h) , with an average value of (1.416± 0.3 nGy/h). The present results have shown that values of absorbed gamma dose rate in all samples studied were less than the recommended value of (55 nGy/h) [10] .

The highest value of indoor annual effective dose equivalent was found in Cicer sample which was equal to (0.01 mSv/y), while the lowest value of indoor annual effective dose equivalent was found in Cicer sample which was equal to (0.004 mSv/y) ,with an average value of (0.007±0.002 mSv/y). The present results have shown that the indoor annual effective dose equivalent in all samples studied were less than the recommended value of (1 mSv/y) [10] .

The highest value of outdoor annual effective dose equivalent was found Cicer sample which was equal to (0.0021 mSv/y) , while the lowest value of outdoor annual effective dose equivalent was found in Rice sample which was equal to (0.0009 mSv/y), with an average value of (0.002± 0.002 mSv/y). The present results have shown that values of outdoor annual effective dose equivalent in all samples studied were less than the recommended value of (1 mSv/y) [10] .

The highest value of internal hazard index was found in Cicer sample which was equal to (0.017), while the lowest value of internal hazard index was found in Rice sample which was equal to (0.006) ,with an average value of (0.012±0.03). The present results have shown that values of internal hazard index in all samples studied were less than the recommended value of (1) [10] .

The highest value of external hazard index was found in Cicer sample which was equal to (0.012), while the lowest value of external hazard index was found in Rice sample which was equal to (0.004), with an average value of (0.009±0.02). The present results have shown that values of external hazard index in all samples studied were less than the recommended value of (1) [10] .

The highest value of activity concentration index was found in Cicer sample which was equal to (0.031), while the lowest value of activity concentration index was found in Rice sample which was equal to (0.012) ,with an average value of (0.022±0.02). The present results have shown that values of activity concentration index in all samples studied were less than the recommended value of (1) [10] .

Table (1) A_U, A_{Th} and A_K with some other parameters [Ra_{eq}, D_γ, $(AED)_{in}$, $(AED)_{out}$, H_{in}, H_{ex} and I_γ] in foodstuffs specimens in all samples.

No.	samples	^{238}U	^{232}Th	^{40}K	Ra_{eq}	D_γ	(A.E.D)		Hazard index		I_γ
							E_{in}	E_{out}	H_{in}	H_{ex}	
1	Flour Emirati	1.360	0.460	1.540	2.136	0.970	0.005	0.001	0.009	0.006	0.015
2	Maize Turkish	1.490	1.730	1.340	4.067	1.789	0.009	0.002	0.015	0.011	0.028
3	Lentil Turkish	1.450	1.460	1.480	3.652	1.613	0.008	0.002	0.014	0.010	0.025
4	Beans Turkish	0.680	1.880	1.220	3.462	1.501	0.007	0.002	0.011	0.009	0.024
5	Rice Indian	0.460	0.740	1.68	1.648	0.730	0.004	0.0009	0.006	0.004	0.012
6	Pasta Iranian	1.510	1.650	1.530	3.987	1.758	0.009	0.002	0.015	0.011	0.028
7	Okra Turkish	1.020	0.810	1.250	2.275	1.013	0.005	0.001	0.009	0.006	0.016
8	Vigna radiata Turkish	0.710	1.320	1.840	2.739	1.202	0.006	0.001	0.009	0.007	0.019
9	Cicer Turkish	1.950	1.680	1.920	4.500	1.996	0.010	0.0021	0.017	0.012	0.031
10	Noodles Saudi	1.570	1.320	1.660	3.585	1.592	0.008	0.002	0.014	0.010	0.025
Avr.		1.220	1.305	1.546	3.205	1.416	0.007	0.002	0.012	0.009	0.022
Min.		0.460	0.460	1.220	1.648	0.730	0.004	0.0009	0.006	0.004	0.012
Max.		1.950	1.880	1.920	4.500	1.996	0.010	0.002	0.017	0.012	0.031
worldwide [6]		35	30	400	370	55	1	1	1	1	1

Conclusion

Measuring natural radioactivity in imported foodstuffs is an important part of ensuring the safety of food consumed, especially in light of the presence of natural and artificial sources of radioactivity. The aftereffects in this work concerning values of the A_U, A_{Th}, A_k and determination_the parameters [Ra_{eq} , D_γ, $(AED)_{in}$, $(AED)_{out}$, H_{in} , H_{ex} and I_γ] ,all results less than their corresponding allowed limits.

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