^{238}U, ^{232}Th and ^{40}K in wheat flour samples of Iraq markets

Ali Abid Abojassim, Husain Hamad Al-Gazaly, Suha Hade Kadhim

University of Kufa, Al.najaf, Iraq

Keywords:

Radioactivity
Wheat
Flour
Food
Iraq
Gamma
Spectroscopy

Article history:

Received 04.07.2014
Received in revised form 08.08.2014
Accepted 02.09.2014

Corresponding author:

Ali Abid Abojassim
E-mail:
ali.alhameedawi@uokufa.edu.iq.

Abstract

Introduction. Wheat flour is a nutritious type of food that is widely consumed by various age groups in Iraq. This study investigates the presence of long-lived gamma emitters in different type of wheat flour in Iraqi market.

Materials and methods. Uranium (^{238}U), Thorium (^{232}Th) and Potassium (^{40}K) specific activity in (Bq/kg) were measured in (12) different types of wheat flours that are available in Iraqi markets. The gamma spectrometry method with a NaI(Tl) detector has been used for radiometric measurements. Also in this study we have calculated the internal hazard index, radium equivalent and absorbed dose rate in all samples.

Results and discussion. It is found that the specific activity in wheat flour samples were varied from (1.086±0.0866) Bq/kg to (12.532±2.026) Bq/kg with an average (6.6025) Bq/kg for ^{238}U, For ^{232}Th From (0.126±0.066) Bq/kg to (4.298±0.388) Bq/kg with an average (1.9465)Bq/kg and for ^{40}K from (41.842±5.875) Bq/kg to (264.729±3.843) Bq/kg with an average (133.097) Bq/kg. Also, it is found that the radium equivalent and the internal hazard index in wheat flour samples ranged from (3.4031) Bq/kg to (35.1523) Bq/kg with an average (19.6346) Bq/kg and from (0.0091) to (0.1219) with an average (0.0708) respectively.

Conclusion. This study prove that the natural radioactivity and radiation hazard indices were lower than the safe.

Introduction

Natural radioactivity is caused by the presence of natural occurring radioactive matter (NORM) in the environment. Examples of natural radionuclides include isotopes of potassium (^{40}K), uranium (^{238}U and its decay series), and thorium (^{232}Th and its decay series). In addition to being long-lived (in the order of 1010 years), these radionuclides are typically present in air, soil, and water in different amounts and levels of activity. Natural radionuclides are found in terrestrial and aquatic food chains, with subsequent transfer to humans through ingestion of food. As such, international efforts were brought together collaboratively to apply adequate procedures in investigating radionuclides in food [1], and to set essential guidelines to protect against high levels of internal exposure that may be caused by food consumption [2,3].

Since wheat flour is one of the essential foods that is consumed in Iraqis daily lives, the desire to establish a national baseline of radioactivity exposure from different types of wheat flour samples that available in Iraq markets is very critical. Wheat flour is a powder made from the grinding of wheat used for human consumption. Wheat flour, the "Staff of Life", has been an essential commodity to human existence through the centuries and is currently the most widely consumed staple food. Moreover, numerous studies were conducted worldwide to investigate natural radionuclides in food consumed in different parts of the world [4-7]. For a systematic treatment, a methodical approach is undertaken that focuses on a wheat flour type of food per study. Because wheat flour is popular among all ages, the current study focuses on investigating the natural radioactive content in all times of food.

Materials and methods

Sample Collection and Preparation. Twelve samples of the most available types of flour were collected from the local markets in Iraq to measure natural activity. The types of samples are listed in Table (1). After collection, each flour sample was kept in a plastic bag and labeled according to its name. These samples were packed in a 1 L polyethylene plastic Marinelli beakers of constant volume to reach a 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 [8].

Table 1

Types and orign of wheat flour samples in this study

No.	Sample code	Name of Samples	Origin of samples
1	F1	Good sentences	Lebanon
2	F2	Fine semolina	Saudi Arabia
3	F3	Altunsa	Turkey
4	F4	Sirage	Turkey
5	F5	Barrash	Turkey
6	F6	Rehab	IRAQ
7	F7	Sankar	Turkey
8	F8	Super	Turkey
9	F9	Donya	Turkey
10	F10	Suphan	Turkey
11	F11	Farina	Turkey
12	F12	Sayf	Turkey

Measurement System. Natural radioactivity levels were measured using a gamma spectrometer which includes gamma multichannel analyzer equipped with NaI(Tl) detector of (3"×3") crystal dimension as Figure (1). The gamma spectra were analyzed using the ORTEC Maestro-32 data acquisition and analysis system. The detector had coaxial closed-facing geometry with the following specifications: The calculated resolution is 7.9% for energy of 661.66 keV of ^{137}Cs standard source. Relative efficiency at 1.33 MeV ^{60}Co was 22.2% and at 1.274 MeV ^{22}Na was 24.4%. The detector was shielded by a cylindrical lead shield in order to achieve the lowest background level. An energy calibration for this detector was performed with a set of standard γ-ray 1-μCi active ^{137}Cs, ^{60}Co, ^{54}Mn, and ^{22}Na sources. In this study, the activity concentration of ^{40}K was determined directly from the peak areas at 1460 keV. The activity concentrations of ^{238}U and ^{232}Th were calculated assuming secular equilibrium with their decay products. The gamma transition lines of ^{214}Bi (1765 keV) were used to calculate activity concentration of radioisotope in the ^{238}U-series. The activity concentrations of radioisotope in the ^{232}Th-series were determined using gamma transition lines of ^{208}Tl (2614 keV). The counting time for each sample was at 18000 sec.

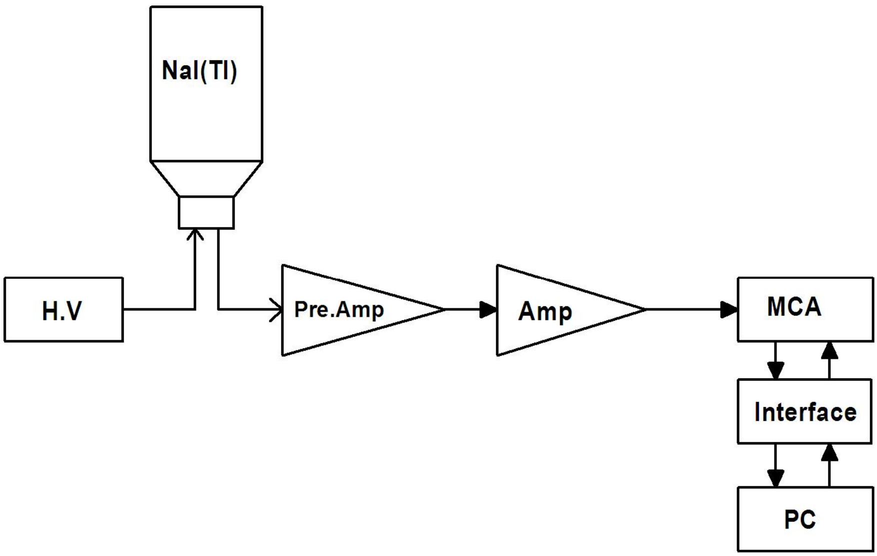

Figure 1. Block diagram of a spectrometer system

Calculation of Activity. Since the counting rate is proportional to the amount of the radioactivity in a sample, the Activity Concentration (*Ac*) which can be determined as a specific activity as the follows [9]:

$$Ac = \frac{C - BG}{\varepsilon\%\, M\, t\, I_{\gamma}} \tag{1}$$

Where *Ac* is the specific activity, *C* is the area under the photo peaks, *ε%* is percentage of energy efficiency. I_γ is the percentage of gamma-emission probability of the radionuclide under consideration, *t* is counting time, *M* is mass of sample and *BG* is background.

Radium Equivalent Activity. Radium equivalent activity (Ra_{eq}) is used to assess the hazards associated with materials that contain ^{238}U, ^{232}Th and ^{40}K in Bq/kg [8], which is, determined by assuming that 370 Bq/kg of ^{226}Ra or 260 Bq/kg of ^{232}Th or 4810 Bq/kg of ^{40}K produce the same γ dose rate. The $Ra_{eq}$of a sample in (Bq/kg) can be achieved using the following relation [8,10,11]:

$$Ra_{eq} = A_U + (1.43 \ x \ A_{Th}) + (A_k x \ 0.077) \quad (2)$$

Internal Hazard Index. This hazard can be quantified by the internal hazard index (H_{in}) [8,12-13]. This is given by the following equation:

$$H_{in} = (A_U/185) + (A_{Th} / 259) + (A_K /4810) \quad (3)$$

The internal hazard index should also be less than one to provide safe levels of radon and its short-lived daughters for the respiratory organs of individuals living in the dwellings.

Results and discussion

The specific activity due to ^{238}U, ^{232}Th and ^{40}K in different kinds of wheat flour samples has been measured as shown in Table (2) and Figures (2), (3) and (4) respectively. The specific activity of ^{238}U was found in the range of (1.086±0.0866) Bq/kg to (12.532±2.026)Bq/kg with an average (6.6025) Bq/kg, ^{232}Th from (0.126±0.066)Bq/kg to (4.298±0.388)Bq/kg with an average (1.9465)Bq/kg and ^{40}K from (41.842±5.875) Bq/kg to (264.729±3.843)Bq/kg with an average (133.097) Bq/kg. The radiation hazard indices, radium equivalent and internal hazard indices were calculated for all samples in this study as shown in Table (3) and Figure (5).The internal hazard (H_{in}) and radium equivalent varied (3.4031)Bq/kg to (35.1523)Bq/kg with an average (19.6346)Bq/kg and from (0.0091) to (0.1219) with an average (0.0708)respectively.

Table 2

Specific activity of ^{238}U, ^{232}Th and ^{40}K in some types of wheat flour

Sample Code	Specific activity in (Bq/Kg)		
	U^{238}	Th^{232}	K^{40}
F1	1.086±0.0866	3.411±0.322	179.089±3.187
F2	9.991± 1.715	3.340±0.356	264.729±3.843
F3	3.391±2.241	0.796±0.504	96.509±2.446
F4	5.102±1.861	2.462±0.475	120.555±5.5134
F5	2.243±2.303	1.646±0.394	47.805±5.025
F6	6.599±1.852	1.375±0.655	100.892±6.289
F7	11.078±2.848	4.298±0.388	79.767±6.499
F8	----------	0.126±0.066	41.842±5.875
F9	6.048±1.526	1.561±0.664	109.061±6.643
F10	6.196±3.127	1.652±0.684	191.549±7.006
F11	12.532±2.026	2.685±0.573	175.257±6.510
F12	6.370±2.307	---------	190.104
Average	**6.6025**	**1.9465**	**133.097**

There is a variation in the specific activity of radionuclides in different wheat flour samples, for example (F1) which is Turkish Farina has lowest ^{238}U concentration, while (F11) which is Lebanese Good sentences has the maximum value, (F8) Turkish Super has the lowest ^{232}Th concentration while the maximum is (F7) also Turkish Sankar, and the lowest ^{40}K concentration is (F8) which is Turkish Super and the maximum is (F2) Saudi Arabia Fine semolina. The results obtained show that the specific activity of ^{238}U, ^{232}Th and ^{40}K in all wheat flour samples appeared lower than recommended limit of UNSCEAR (2008) [15].The values of all the radiation hazard indices in this study (radium equivalent and internal hazard indices)are lowest value in sample (F8) Turkish Superand and the highest value in sample (F2) Saudi Arabia Fine semolina. The result of the radiation hazard indices are lower than recommended limit of UNSCEAR (2008)[15].

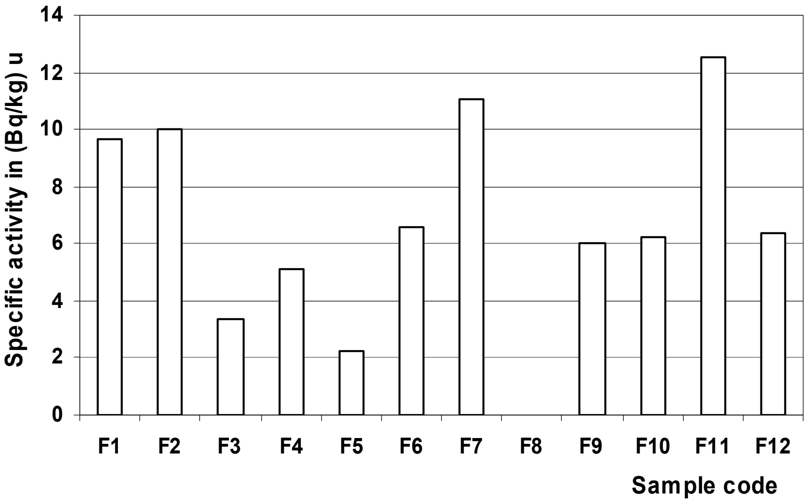

Figure 2. Specific Activity of ^{238}U in (Bq/Kg)

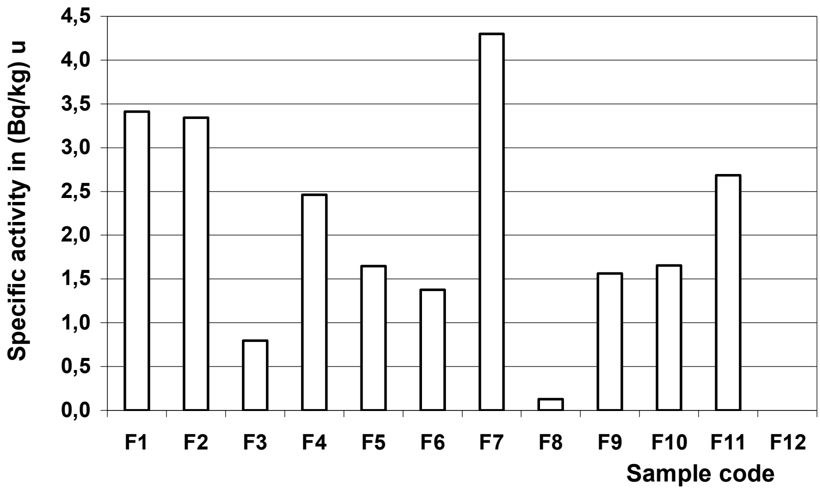

Figure 3. Specific Activity of ^{232}Th in (Bq/Kg)

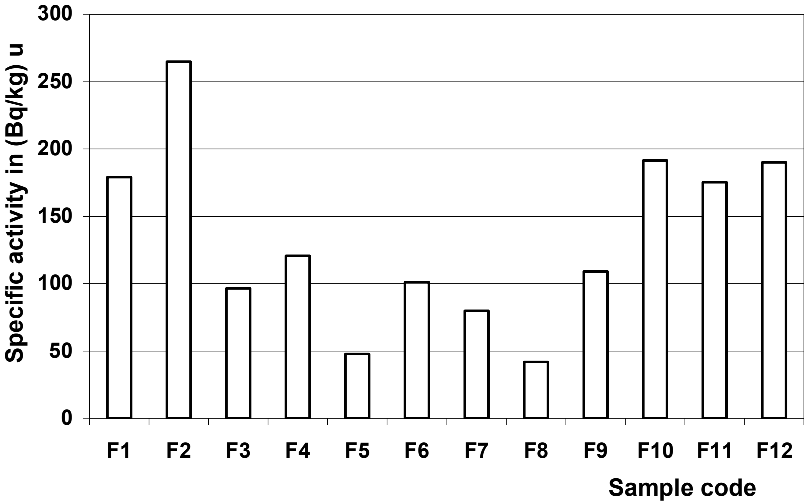

Figure 4. Specific Activity of ^{40}K in (Bq/Kg)

Table 3
Radiological hazard indexes in some types of wheat flour

Sample Code	H_{in}	Raeq (Bq/kg)
F1	0.1027	28.3441
F2	0.1219	35.1523
F3	0.0414	11.9621
F4	0.0621	17.9068
F5	0.0284	8.2789
F6	0.0619	16.335
F7	0.0931	23.3670
F8	0.0091	3.4031
F9	0.0614	16.6801
F10	0.0797	23.309
F11	0.1145	29.8681
F12	0.07395	21.0081
Average	**0.0708**	**19.6346**

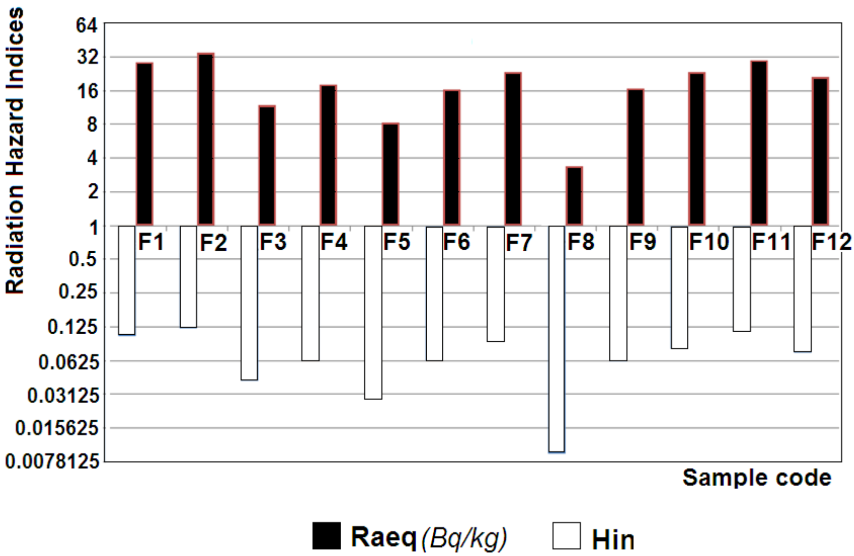

Figure 5. A radiation hazard indexes for wheat flour samples

Conclusions

The present study is the important at the national level to investigate radioactivity of wheat flour that is available in Iraqi markets. It is found that consumption of wheat flour as the foodstuff is safe for all ages of people in Iraq. The findings of this work will help in establishing a baseline of radioactivity exposure to the general public from ingestion of foodstuff.

Acknowledgements. *I would like to knowledge all those contributed in declaring this issue. Special thanks to the staff of the department of physics at Kufa university.*

References

1. IAEA, International Atomic Energy Agency (1989), Measurements of Radionuclides in Food and Environment, *A Guidebook, Technical Reports Series*, 295, pp. 230.
2. ICRP, International Commission on Radiological Protection (1996), Age-Dependent Doses to Members of the Public from Intake of Radionuclides, *Part 5 Compilations of In-gestion and Inhalation Dose Coefficients (ICRP Publica-tion 72)*, Pergamon Press, Oxford.
3. UNSCEAR, Sources, Effects and Risks of Ionizing Ra-diation (2000), *Report to the General Assembly, United Nations Committee on the Effects of Atomic Radiation*, New York.
4. Hosseini T., Fathivand A.A., Abbasisiar, Karimi M., Barati H. (2006), Assessment of

annual effective dose from U-238 and Ra-226 due to consumption of foodstuffs by inhabitants of Tehran city, Iran, *Radiation Protection Dosimetry*, 121, pp. 330-332.

5. Jibiri N.N. and Okusanya A.A., (2008), Radionuclide contents in food products from domestic and imported sources in Nigeria, *Journal of Radiological Protection*, 28, pp. 405-413.
6. Ababneh Z.Q., Alyassin A.M., Aljarrah K.M., Ababneh A.M. (2009), Measurement of natural and artificial radioactivity in powdered milk consumed in Jordan and estimates of the corresponding annual effective dose, *Radiat. Prot. Dosimetry*, 38, pp. 278-283.
7. Desimoni J., Sives F., Errico L., Mastrantonio G., Taylor M.A. (2009), Activity levels of gamma-emitters in Argentinean cow milk, *Journal of Food Composition and Analysis*, 22, pp. 250-253.
8. Nasim A., Sabiha J. and Tufail M. (2012), Enhancement of natural radioactivity in fertilized soil of Faisalabad, Pakistan, *Environ SciPollut Res*, 19, pp. 3327–3338.
9. Maduar M. and.Junior P. (2007), Gamma Spectrometry In the Determination of Radionuclides Comprised In Radioactivity Series, *International Nuclear Atlantic Conference-INC*, Santos SP, Brazil.
10. Singh S., Rani A. and Mahajan R. (2005), ^{226}Ra, ^{232}Th and ^{40}K analysis in soil samples from some areas of Punjab and Himachal Pradesh, India using gamma ray spectrometry, *Radiation Measurement*, 39, pp. 431–439.
11. Yu K., Guan Z., Stoks M. and Young E. (1992), The assessment of natural radiation dose committed to the Hong Kong people, Journal of environmental ra*d*ioactivity, 17, pp. 31-48.
12. El-Arabi A. (2007), ^{226}Ra, ^{232}Th and ^{40}K concentrations in igneous rocks from eastern desert, Egypt and its radiological implication", *Radiation Measurement*, 42, pp. 94–100.
13. Quindos L., Fernandez P. and Soto J. (1987), Building materials as source of exposure in houses. In Indoor Air 87 (eds Seifert, B. and Esdorn, H., Institute of Water, Soil and Air Hygiene), *Berlin*, 2, pp. 365.
14. United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR) (1993), Sources and effects of ionizing *radiation*, UN, New York.
15. United Nations Scientific Committee on Effects of Atomic Radiation (UNSCEAR) (2008), Report to the General Assembly, *Sources and Effects of Ionizing Radiation*, New York.