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Assessment of natural radioactivity levels and other related radiation quantities in white rice from different countries consumed in Qassim, Saudi Arabia

By

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Abstract: Measuring the concentration of radioactivity in rice is important in order to determine the exposure of people to radiation from radionuclides in nature while eating their usual food. All types of foods, including rice, contain a detectable amount of natural radioactivity that is transmitted, respectively, to humans through food. The current study focused on measuring the radionuclide concentration of radium ^{226}Ra, thorium ^{232}Th and potassium ^{40}K of white rice consumed in the Qassim markets in the Kingdom of Saudi Arabia for five countries (America, Egypt, Thailand, India and Vietnam) using the NaI (TL) gamma ray spectrometer. Also, the absorbed dose of the samples under study was calculated, as well as their radium equivalent. Also, the radiation accompanying parameters for the radiological hazard indicators were calculated in order to know if the values were appropriate for the internationally determined results.

Keywords:

Radionuclides, concentration of radioactivity, radiation-accompanying parameters, NaI (TL)gamma ray spectrometer.

1. Introduction

Human exposure to radiation from natural sources is common, such as cosmic rays, radiation from the Earth's crust, and radiation from radon gas. Humans are also exposed to additional doses resulting from the scientific development in which radioisotopes have been used in many modern technologies in medicine, agriculture, and industry. Humans are primarily exposed to ionizing radiation from naturally occurring radionuclides from ^{40}K and radionuclides from decay products from the ^{226}Ra and ^{232}Th.

In this study, the natural radioactivity of white rice samples from five countries (America - Egypt - India - Vietnam - Thailand) will be measured by measuring the level of natural radiation represented by the measurement of radioactivity, the absorbed dose, radium equivalent and radioactive hazard indicators for potassium ^{40}K, thorium ^{232}Th and radium ^{226} Ra for a number of five samples. In order to protect the person from the danger of radioactive doses that accumulate in his body as a result of eating certain foods in a permanent way and Rice is the main food for most of the people of the world, so the current study focused on measuring the level of radioactivity in rice.

2. Material and Method

2.1 Sample collection and preparation:

Five samples of white rice sold in the Qassim markets were collected from America, Thailand, India, Egypt and Vietnam.

The rice was ground well and then transfered the collected samples to the laboratory. Drying was conducted at a temperature of 100ºC to remove moisture and obtain a stable dry weight. Finally the samples were placed in polyethylene plastic containers for a month before the measurements, allowing radiative balance and eliminating any traces of radon gas in the sample.

2.2 Instrumentation and calibration:

The gamma ray spectrometer used for measuring the activity concentrations was scintillation detector of NaI (Tl) type coupled to PC-MCA with known energy sources.

The detector is isolated from the surrounding medium with a lead shield to reduce the natural radiation.

The counting time for samples, which ranged between 6h to 24h for each sample and each sample is measured three in order to calculate the random errors in measurements.

2.3 Method of calculating the concentration of natural radioactivity:

The concentration of radioactivity in the samples for ^{226}Ra, ^{232}Th and ^{40}K is measured as follows:

for Calculating the radium concentration ^{226}Ra the energies were used for the following isotopes: Lead is ^{214}pb and ^{214}Bi to calculate the counting rate

for Calculating the thorium concentration of ^{232}Th The following isotope energy was used ^{228}Ac and ^{212}pb to calculate the counting rate

for calculating the potassium concentration of 40K A single energy count rate calculation was used at the gamma line

The radioactivity of each sample was measured three times, then the mean value of the radioactivity was calculated. In table (1) all the energy lines are given with others related quantities.

Table(1): Data required for calculation of Natural Radioactivity concentration

Nuclide	**Isotopes**	**Energy (KeV)**	**Measured Efficiency for gamma-ray peak (ε)%**	**Abundance of gamma peak in radionuclide (P_r)**
^{226}Ra	^{214}pb	351.9	37	0.21
	^{214}Bi	609.3	46	0.12
	^{214}Bi	1120.3	15	0.08
	^{214}Bi	1764.5	15.9	0.067
^{232}Th	^{228}Ac	911.10	29	0.09
	^{212}pb	238.60	44	0.25
^{40}K	^{40}K	1460.00	11	0.07

The following equation was used to calculate the concentration in unit of (Bq / Kg) [1,2,3,4]:

$$A_s\left({}^{Bq}/_{kg}\right) = \frac{C_s}{\in P_r M_s} \qquad (1)$$

Where:

C_s is the average count of the net per second in units of (Bq), ε is the efficiency of the detector for the radioactive element,

_P_r is the abundance of the isotope and M_s is sample weight in units (Kg).

2.4 Method of Absorbed Dose Rate (D_R):

It is the amount of absorbed dose in the open air at a height of 1Km and was estimated in nano-Gry per hour (nGy / h). It is the amount expressed in the open air resulting from the radiation emitted by the concentration of radioactive isotopes in the environment. It is considered an important parameter to assess health risks. Its value can be estimated using the following equation [1,2,3,4]

$$D_R(nGy/h) = 0.427A_{Ra} + 0.683A_{Th} + 0.043A_K \qquad (2)$$

Where: A_{Ra}, A_{Th}, and A_K are the concentrations of radium, thorium, and potassium, respectively, in units (Bq / Kg).

2.5 Radium Equivalent Activities (Raeq):

Radiation hazards resulting from isotopes that emit gamma rays are expressed in a number of parameters, the most important and the most widely used is the radium equivalent of radiation, which is the weight of the total radiation emitted from the three sources, and it is based on the calculation that 370 Bq / kg of radium ^{226}Ra, 259 Bq /kg of thorium ^{232}Th, 481 Bq/kg of potassium ^{40}K gives the same rates of gamma ray dose and is measured in Bq/Kg unit and its value can be estimated by the following relationship [1,2,3,4]:

$$R_{aeq} = A_{Ra} + 1.43A_{Th} + 0.077A_K \qquad (3)$$

The radium equivalent should not exceed 370 Bq/Kg, which is the value determined by the International Atomic Energy Commission (IAEA) [1,2,3,4].

2.6 Hazard Index:

A. External risk index: The following is the external risk index for the samples under study [1,2,3,4]

$$H_{ex} = \frac{A_{Ra}}{370} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \qquad (4)$$

B. Internal risk index: The following is the internal risk index for the samples under study [1,2,3,4]

$$H_{in} = \frac{A_{Ra}}{185} + \frac{A_{Th}}{259} + \frac{A_K}{4810} \qquad (5)$$

C. Representative Level Index:

Radiation dangers due to radionuclides were evaluated by another indicator called the representation level indicator (Ir) and calculated by the following equation [1,2,3,4].

$$I_r = \frac{A_{Ra}}{150} + \frac{A_{Th}}{100} + \frac{A_K}{1500} \qquad (6)$$

3. Results and Discussions

Using the equations (1-4), the mean concentration, absorbed dose and radium equivalent of five rice samples from five countries were calculated and the results are given in Table (2) and shown in Fig (1-3)

You may notice in the fig(1) that the radium concentration in the samples ranged between 0.99-0.65Bq/Kg. The highest concentration was in Egyptian rice and the lowest concentration in rice from the country of Vietnam. The absorbed dose in the samples ranged between 0.66-1.87 nGy / hr as shown in Fig(2)and was higher in American rice and less in rice of Vietnam.

Also, the radium equivalent was calculated in the samples. The values ranged between 1.45-6.35Bq/Kg as shown in Fig(3) and the highest value was in American rice and the lowest in Vietnam.

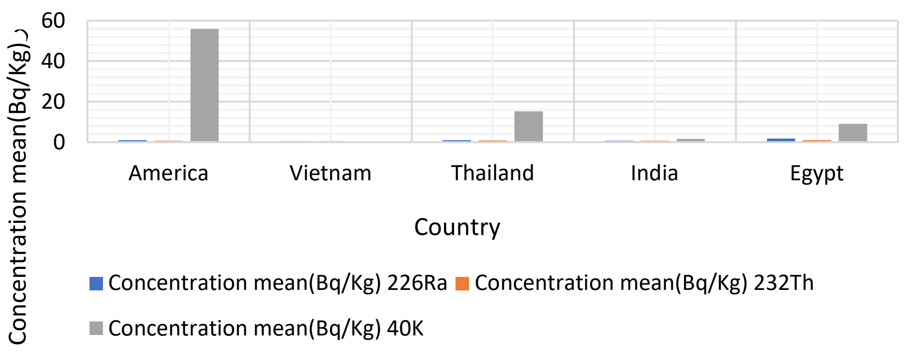
Also, the external and internal radiation risk indicators and the representation factor were calculated as shown in Table (3) and all indicators were less than the unity, which indicates that the radiation safety of rice from the mentioned countries.

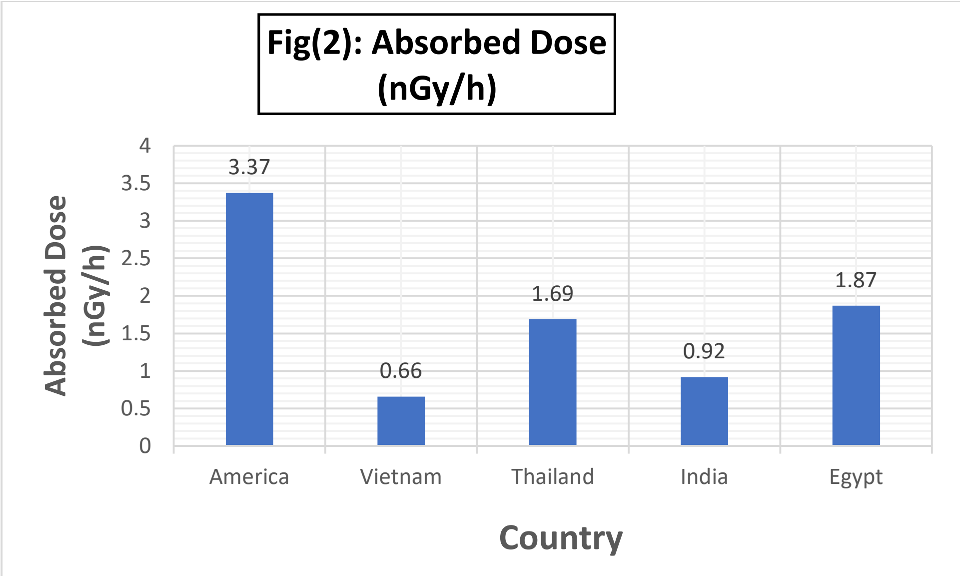
In Table (4) The comparison of the potassium concentration ^{40}K, radium ^{226}Ra, and thorium ^{232}Th in the present study with others are given[5,6]. The current study were found to be close to the study of Bangladesh [6] and is lower than the values of Nigeria

Table (2): concentration and radiation dose and Radium Equivalent Activities of Potassium ^{40}K, Radium ^{226}Ra, and thorium ^{232}Th in the present samples.

Mean of concentratiom (Bq/Kg)			Radium Equivalent (Bq/Kg)	Absorbed Dose (nGy/h)	Country
^{40}K	^{232}Th	^{226}Ra	-	-	
55.89±8.70	0.74±0.08	0.99±0.66	6.35	3.37	America
0.03±0.04	0.62±0.22	0.56±0.74	1.45	0.66	Vietnam
15.30±2.02	0.90±0.14	0.99±0.24	3.46	1.69	Thailand
1.75±2.3	0.75±0.07	0.79±0.24	2.00	0.92	India
9.17±6.11	0.99±0.61	1.88±0.93	4.00	1.87	Egypt

Fig(1): Mean concentration of Potassium ^{40}K, Radium ^{226}Ra, and thorium ^{232}Th in the present samples.




Fig(2): Absorbed Dose (nGy/h)
Absorbed Dose (nGy/h)
4
3.5
3
2.5
2
1.5
1
0.5
0
3.37
0.66
1.69
0.92
1.87
America
Vietnam
Thailand
India
Egypt
Country

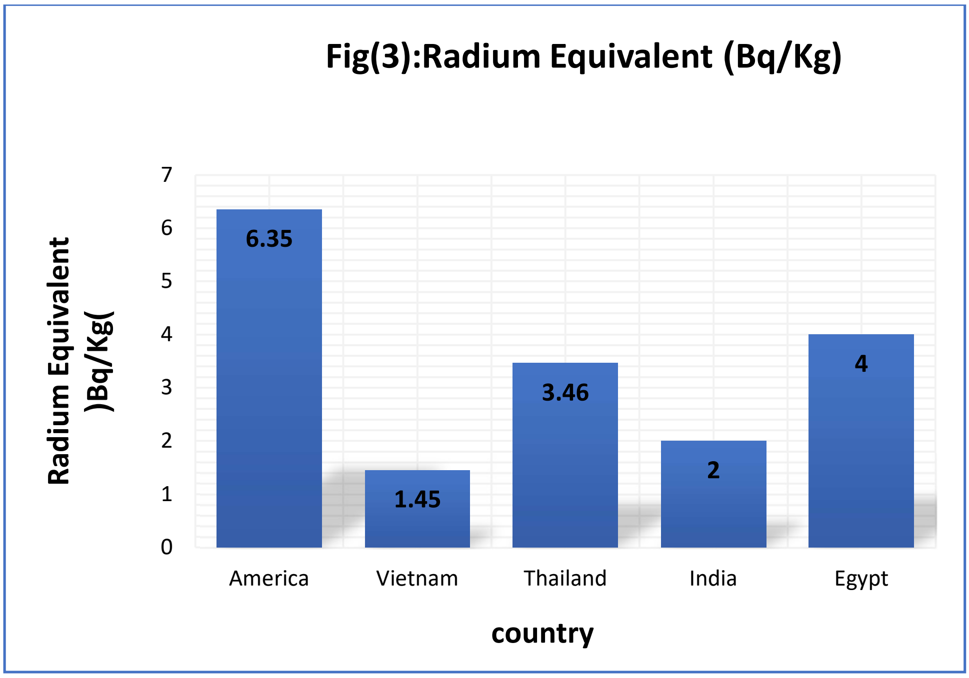

Fig(3):Radium Equivalent (Bq/Kg)
Radium Equivalent)Bq/Kg(
7
6
5
4
3
2
1
0
6.35
1.45
3.46
2
4
America
Vietnam
Thailand
India
Egypt
country

Table (3) Indicators of External($\mathbf{H_{ex}}$) and Internal Radiation Hazards($\mathbf{H_{in}}$) and Representative Level Index ($\mathbf{I_r}$):

$\mathbf{I_r}$	$\mathbf{H_{in}}$	$\mathbf{H_{ex}}$	**Country**
0.051	**0.019**	**0.017**	America
0.009	**0.005**	**0.004**	Vietnam
0.026	**0.012**	**0.009**	Thailand
0.014	**0.008**	**0.005**	India
0.029	**0.016**	**0.011**	Egypt

Table(4): comparison between Rice mean Concentration in the present work with Others

(Ref)	**Mean concentration in Bq/Kg**			**Country**
-	$\mathbf{^{40}K}$	$\mathbf{^{232}Th}$	$\mathbf{^{226}Ra}$	**-**
Present work	**0.03-55.89**	**0.62-0.99**	**0.56-1.88**	**Saudi Arabia-Qassim Markets**
5	**45-275.2**	**0.1-2.3**	**0.1-2.6**	**Saudi Arabia-Qassim Markets**
6	**41.15-61.01**	**9.89-10.36**	**7.28-12.73**	**Nigeria**
6	1.09-9.23	0.04-0.49	0.47-1.66	Bangladesh

4. Conclusions

In this study, the radioactivity concentration of ^{40}K potassium, radium ^{226}Ra, and thorium ^{232}Th and the accompanying quantities were measured and the following facts were reached:

1. The average value of the radioactivity of radium and thorium ranged between 0.56-1.88 Bq/Kg and 0.62-0.99Bq/Kg respectively, and the highest recorded value of radium and thorium was in rice from Egypt and the lowest value for the rice sample was from the sample of Vietnam, respectively.

2. The average value of the radioactivity of potassium ranged between 0.03-55.89 Bq/Kg. The highest recorded value of rice was from the American sample, which is an expected value and the lowest value for the Vietnam sample, which is a very low value compared to the levels of radioactivity of potassium in different rice samples.

3. As for the absorbed dose, it ranged between 0.66-3.36nGy/hr and the highest dose value in the rice sample was from the American country due to the high potassium concentration in the American sample which is more safer than the other radioactive materials thorium and radium and the lowest was the Vietnam sample.

4. For radium equivalent, the values in the measured samples ranged from 1.45-6.35Bq/kg The highest dose value in the rice sample was from the country of America due to the concentration of potassium which is more safer than other radioactive materials of thorium and radium and the lowest was the sample of Vietnam

5. External and internal radiological risk indicators were also calculated and the representation index. All of these indicators were less than the unity, indicating the radiation security of the rice samples

6. The current study was compared with a number of previous studies. The current study was consistent with previous studies in the concentration of thorium and radium. As for potassium, the current study close to the Bangladesh study.

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