Estimation the cancer risk due to ingestion the food spices commonly used in Iraqi kitchen

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Abstract. Spices are natural substances taken from special plants and have a different taste when added to food and some of them have great benefits for health and body. These plants vary from country to country depending on the type of soil and how they are grown and this affects their quality. In this study, the specific activity of 40K, 238U and 232Th series and 137Cs in some selected natural food spices commonly used in Iraq kitchen were determined using gamma spectrometry and the ingested doses via food consumption were also assessed. The average specific activity of 40K, 238U, 232Th and 137Cs in the samples are 72.00 Bqkg⁻¹, 106.576 Bqkg⁻¹, 148.74 and 191.88 Bq.kg⁻¹ respectively. The highest activity concentration of 40K, 238U, 232Th and 137Cs was recorded in cumin (401.7) for 40K, laurel paper (260.67) for 238U, briana spices (733.7) for 232Th and Chamomile (833.4) for 137Cs. The maximum value of total annual effective dose received from 40K, 238U, 232Th and 137Cs due to consumption of natural spices by the inhabitants was 169.83 µSv.y⁻¹. This value is low compared to the average radiation dose of 290 µSv.y⁻¹ received per caput worldwide due to ingestion the food spices. The excess lifetime cancer risk due to ingestion of radionuclide in food spices was estimated and the values obtained were compared with standards. Based on these results it can be concluded that the foods spices studied in this work do not present any serious radiological effect. Spices are natural substances taken from special plants and have a different taste when added

Keywords: Spice samples, Gamma spectroscopy, Cancer Risk, specific activity.
1. Introduction

Everything on the earth contains a small amount of radioactive material. Heavy metals and gamma radioactive elements are found in fruits, vegetables and plants [1]. Determining the level of radioactivity in the environment and foodstuffs is critical to controlling the amount of radiation to which humans are directly or indirectly exposed [2].

Knowledge of the concentrations of the radionuclides in spices is the important topics as it provides helpful information in the monitoring of environmental radioactivity.

Spices come from the bark, roots, seeds, fruit of plants and trees, they are used as recipes to add flavor to dishes, and they play an important role in the general makeup of culinary art [3]. Foods and spices can be contaminated either through deposition in the atmosphere or transferred by water through the soil. Two types of spices inspired in Iraq the fresh ones and those have been processed into powdered or solid forms. Assessment of contamination of spices consume by the population is very important to know the baseline value, or the level of radiation dose of both natural and artificial radionuclide received by them.

Various workers as in refs [4-7] have reported determination of different radionuclides concentration in food and spices samples. In this study, the radioactivity levels of $^{40}$K, $^{238}$U, $^{232}$Th and $^{137}$Cs in natural food spices were estimated using gamma spectrometry. These spices were purchased from different traders at the mile one market in the Baghdad city, Iraq. This study, therefore, investigated the extent of the exposure of the public due to intake of spices as part of the national effort to establish base line values for the Regulatory Authorities to control the exposure of the public to the natural and artificial radionuclides due to the consumption of spices in Iraq.

2. Materials and Methods

2.1. Sampling and samples preparing

Food spices samples were collected from the Iraqi local market, fifteen samples were collected, every one of these samples weight about 1000 g. The types of samples are listed in Table 1. The homogenized rice samples were sealed in plastic containers and left for at least 4 weeks to reach a secular equilibrium between parent radionuclides and daughters [8].

![Table 1. The types of samples](table.png)
2.2. Gamma spectroscopy
In this study, the technique of spectral analysis of gamma rays is used. The detector and measurement system is shown in Fig. 1, consists of NaI (TI) detector with a size of (3”×3”), the voltage of 691 V, the efficiency of 60%, and the energy resolution (6.5-8.56%) for value energy (661-1332) keV.

Figure. 1 A scheme for gamma ray spectroscopy with NaI (TI) detector.

3. Results and discussion

3.1. Specific activity for natural radioactivity in the food spices samples
The specific activity of $^{238}$U, $^{232}$Th, $^{40}$K and $^{137}$Cs in samples of food spices commonly consumed by the Iraqi population are presented in Table 2. The activity concentration for $^{40}$K in the spices samples ranged from 0.0 Bq/kg to 401.7 Bq/kg in sample 3, the mean value of $^{40}$K in the samples was 72 Bq/kg. The specific activity of $^{238}$U in the food spice samples ranged from 0.0 Bq/kg to 260.67 Bq/kg in sample 6 and the mean value of $^{238}$U in the samples was 106.576 Bq/kg. The activity concentration of $^{232}$Th ranged from 0.0 Bq/kg to 733.7 Bq/kg in sample 2 with a mean value of 148.74 Bq/kg. Fig. 2 represents the activity concentration of $^{238}$U, $^{232}$Th, $^{40}$K and $^{137}$Cs in various food spices.

Table 2. Specific activity in (Bq/kg) of $^{40}$K, $^{232}$Th, $^{238}$U and $^{137}$Cs in food spices samples

| Sample No. | $^{238}$U | $^{232}$Th | $^{40}$K  | $^{137}$Cs |
|------------|-----------|-----------|---------|-----------|
| 1          | 0         | 0         | 0       | 0         |
| 2          | 0         | 733.7     | 175.3   | 0         |
| 3          | 122.12    | 0         | 401.7   | 115.5     |
| 4          | 0         | 0         | 0       | 0         |
| 5          | 214.50    | 0         | 74.53   | 629.5     |
| 6          | 260.67    | 372.6     | 161.5   | 323.5     |
| 7          | 71.25     | 543.47    | 0       | 135.4     |
| 8          | 167.48    | 0         | 146     | 0         |
| 9          | 0         | 289.8     | 1.187   | 0         |
| 10         | 13.66     | 0         | 0       | 833.4     |
| 11         | 148.3     | 0         | 73.6    | 633       |
| 12         | 189.5     | 0         | 13.24   | 174.7     |
| 13         | 167.4     | 253.6     | 33.25   | 0         |
| 14         | 180.6     | 38.04     | 0       | 33.25     |
| 15         | 63.17     | 0         | 0       | 0         |
3.2. Estimation of Annual Effective Dose and Dose Rate from Ingested Food Spices

The effective dose due to consumption of food spices comes in handy for the possibility of summing up different radionuclides which of course may come from different radioactive sources. These ingested radiation doses can be quantified by measuring the activity concentration (Bq/kg\textsuperscript{-1}) of the radionuclide in the food spices and then multiplied by the masses of these food spices consumed over a given timeframe (kg/day or kg/year) and a dose conversion factor (Sv/Bq) given for each radionuclide and can be appropriately applied the equation:

\[ E = \Sigma (A_s \times I_s \times DCF) \]  

where, \(E\) = Annual Effective Dose equivalent by ingestion of the radionuclides (Sv/\text{y}), \(A_s\) = Activity concentration of radionuclides in the sample (Bq/kg), \(I_s\) = Annual intake of the food spices (kg/\text{y}), \(DCF\) = internal dose conversion factor by ingestion of the radionuclides (Sv/Bq). This is given as 0.28 \(\mu\text{Sv/Bq}\) for \(^{238}\text{U}\), 0.23 \(\mu\text{Sv/Bq}\) for \(^{232}\text{Th}\), 0.0062 \(\mu\text{Sv/Bq}\) for \(^{40}\text{K}\) and 0.013 \(\mu\text{Sv/Bq}\) for \(^{137}\text{Cs}\) \[9\]. In this study the consumption values for locally produced food spices correspond to those of the adult citizen. The scale of the annual intake (1 kg/\text{y}) \[10\] was used. The risk associated with the intake of radionuclides in the body is proportional to the total internal dose delivered by the radionuclides.

Table 3, presents the annual effective dose equivalent of \(^{238}\text{U}, \, ^{232}\text{Th}, \, ^{40}\text{K}\) and \(^{137}\text{Cs}\) radionuclides and the total dose due to the four radionuclides in food spices samples. From this Table, the annual effective ingestion doses due to the intake of \(^{238}\text{U}\) varied from 0.0\(\mu\text{Sv/y}\)\textsuperscript{-1} to 72.8 \(\mu\text{Sv/y}\)\textsuperscript{-1} in sample 6. Most samples show insignificant low ingestion doses over the values of 6.3 \(\mu\text{Sv/y}\)\textsuperscript{-1} reported by UNSCEAR, \[11\]. The dose received from \(^{232}\text{Th}\) due to consumption of food spices varied from 0.00 in samples to 8.75 \(\mu\text{Sv/y}\)\textsuperscript{-1} in sample 14. The values of effective dose from the ingestion of \(^{40}\text{K}\) ranged...
from 0.00 to 2.49 μSv-1 in sample 3. Thus, the contribution to dose from the ingestion of 40K in food spices with its relatively low dose conversion factor will be much less than that for the thorium 232-Th but higher than that for 238-U. The mean annual effective dose from 238-U, 232-Th, 40K and 137Cs in food spices were estimated to be 30.5, 38.22, 0.446 and 2.74 μSv-1 respectively. The highest mean annual internal dose was 232-Th and all their mean doses are less than annual dose limit of 1 mSv-1 for the general public. The UNSCEAR, [11] report shows that the sub-total ingestion dose of uranium and thorium series is given as 120μSv-1 which is higher than the sub-total dose for the results reported in this study for uranium and thorium. The total effective dose ranged from 0.0 μSv-1(sample 1) to 152.3 μSv-1 sample (11) with an average value of 64.62 μSv-1 as shown in Fig.3. These values are much less than the world total food dose value of 290 μSv-1 for all foods [11]. The low values of effective dose due to intake of spices are due to low annual intake of only 1 kgy-1 when compared to a few hundred kgy-1 for the total food intake.

Table 3: Annual effective dose equivalent (AEDE) in (μSv-1) of 40K, 232-Th , 238-U and 137Cs in food spices samples and the cancer risk parameters.

| Sample No. | Annual effective dose equivalent (AEDE) (μSv-1) | D (μSv/y) | ELCR × 10^-4 |
|------------|-----------------------------------------------|-----------|---------------|
|            | Ra-226                          | Bi-214    | K-40          | Cs-137          |               |
| 1          | 0                               | 0         | 0             | 0               | 0             |
| 2          | 0                               | 168.75    | 1.08          | 0               | 169.83        | 4.2           |
| 3          | 34.19                           | 0         | 2.49          | 2.079           | 38.759        | 0.97          |
| 4          | 0                               | 0         | 0             | 0               | 33.534        | 0.84          |
| 5          | 60.06                           | 0         | 0.462         | 11.33           | 71.853        | 1.8           |
| 6          | 72.8                            | 104.3     | 1.00          | 4.2             | 83.2          | 208           |
| 7          | 19.95                           | 152.2     | 0             | 1.76            | 21.71         | 54.27         |
| 8          | 46.9                            | 0         | 0.9           | 0               | 47.8          | 119.5         |
| 9          | 0                               | 81.1      | 0.007         | 0               | 81.11         | 202.7         |
| 10         | 3.82                            | 0         | 0             | 10.83           | 45.15         | 112.8         |
| 11         | 51.6                            | 0         | 0.46          | 8.23            | 152.3         | 380.7         |
| 12         | 53.06                           | 0         | 0.082         | 2.27            | 55.41         | 183.5         |
| 13         | 46.87                           | 58.32     | 0.21          | 0               | 47.08         | 117.7         |
| 14         | 50.57                           | 8.75      | 0             | 0.43            | 51.00         | 127.5         |
| 15         | 17.69                           | 0         | 0             | 0               | 70.59         | 176.48        |
| Ave.       | 30.5                            | 38.22     | 0.446         | 2.74            | 64.62         | 112.73        |

3.3. Excess Lifetime Cancer Risk (ELCR)

To estimate cancer risk for an adult person using the following relationship [12]:

\[ ELCR = Cd \times RF \ (Sv^{-1}) \]  \[ \text{……………… (2)} \]

where RF is a risk factor (Sv-1), fatal cancer risk per Sever. For stochastic effects, ICRP 60 uses values of 0.05 for the public [13]. Cd is the lifetime effective dose which is a measure of the total effective dose received over an average lifetime of 50y following ingestion of a radionuclide was calculated using [11]:

\[ Cd = 50 \times D \]  \[ \text{………………… (3)} \]

where D is the total effective dose to an individual.

The calculated cancer risk due to ingestion of food spices was shown in Table 3. The values of cancer risk were ranged from 0.00 to 380.7×10^-4 with an average value of 112.73×10^-4 as shown in Fig. 4.
The mean value of ELCR is lower than the world average value of $2.9 \times 10^{-4}$ based on annual dose limit of 1 mSv for the general public [11].

![Figure 3](image1.png)

**Figure 3.** Annual effective dose equivalent (AEDE) ($\mu$Sv$^{-1}$) in food spices

![Figure 4](image2.png)

**Figure 4.** Cancer risk due to the ingestion of food spices.

4. Conclusions
This work was done to estimate the activity concentration of radionuclides $^{226}$Ra, $^{232}$Th and $^{40}$K using gamma ray spectrometry in different spices that are consumed in Iraqi kitchen. The highest activity concentration of $^{40}$K, $^{238}$U, $^{232}$Th and $^{137}$Cs was recorded in kimono for $^{40}$K, Laurel paper for $^{238}$U,
Briana spices for $^{232}$Th and Chamomile for $^{137}$Cs. The estimated total annual effective dose received from $^{40}$K, $^{238}$U, $^{232}$Th and $^{137}$Cs due to consumption of natural spices is far below the average radiation dose of 290 µSv·y$^{-1}$ received per caput worldwide due to ingestion of natural radionuclide in food spices. The mean value of cancer risk is lower than the world average value of $2.9 \times 10^{-4}$ based on annual dose limit of 1 mSv for the general public. From the results, it is clear that the food spices can be used as human diet for the control of activity. Some of these spices should be used in limited amount.

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