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Study of Radioactivity Pollution in Various Foods from Local Market by Gamma – Ray Spectrometry

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ABSTRACT

Uranium, Thorium and Potassium are naturally occurring radioactive materials present in soil, and therefore radioactivity can be found in the food chain. Consumption of food contaminated with radioactive materials may cause risk of injury from internal radiation exposure.

In the present work, thirty five samples of different types of food materials were collected from the local markets, e.g. seeds, spices, fish, vegetables, rice, tea, coffee, milk, black honey… etc. These were studied, using gamma ray spectrometry to determine the radioactive content of uranium, thorium and potassium, and to evaluate the safety of eating such foods.

From the results, it was observed that the maximum concentration values are (20.74), (20.08), (7.93) and (1179.54) Bq/kg for uranium, radium, thorium and potassium respectively.

It is noted from the present results that it is safe to eat the above samples yet the accumulation of large amounts may produce high doses of radiation to people, especially that cesium was detected in twelve samples, and the maximum concentration was 4.39 Bq/kg.

Key words: *gamma ray spectrometer/ food/ natural radioactivity/ cesium*

INTRODUCTION

The natural radioactivity in the environment is just about the same today as it was at the beginning of the Neolithic Age, more than 10,000 years ago. Most radioactive substances enter our bodies as part of food, water or air. Our bodies use the radioactive as well as the non-radioactive forms of vital nutrients. Radioactivity can be found at every step of the food chain.

Uranium and thorium are naturally occurring radioactive materials present in soil. Each decays through a sequence or decay chain of radionuclides[1-6]. The foods we eat contain varying concentrations of radium-226, thorium-232, potassium-40, carbon-14, and hydrogen-3, depending on the food item. The U. S. Department of Energy gives the following concentrations as examples: Salad Oil 4,900 pCi/l; Milk 1,400 pCi/l; Tap Water 20 pCi/l; Brazil Nuts 14.00 pCi/g; Bananas 3.00 pCi/g; Tea 0.40 pCi/g; Flour 0.14 pCi/g; and Peanuts and Peanut butter 0.12 pCi/g.

Iodine, strontium, and cesium are the most important radio nuclides that enter the food chain and are absorbed by man from the intestinal tract. A radioactive isotope of cesium, Cesium-137, is found in the fallout from the detonation of nuclear weapons and the waste from nuclear power plants. Cesium-137 is one of the most common radioisotopes used in industry. It is used in various measuring devices, such as moisture-density gauges.

Cesium-137 is absorbed and used the same way as potassium. Meat and milk are the primary sources of Cs-137. Much precipitation, lack of minerals in the soil, and extensive cultivation increase the plants' absorption of Cs-137; and thus, the contamination of plant products. Contamination with cesium-137 can cause serious illness or death, depending upon the dose, and has been associated with the development of cancer long after exposure [(7-12)]

In Egypt, the total uranium content in plant samples collected from North Cost of the Delta, the core of the Delta, the East and West of the Delta, ranged from 0.4 to 2 Bq/kg dry weights. The natural activity concentrations of uranium, thorium, and potassium in plant samples collected from South of Sinai ranged from 1.14 to 11.9 Bq/kg, 1.2-9.11 Bq/kg, and 34.48 – 1680 Bq/kg respectively. For Cs-137 the concentration values ranged from 0.05 to 2.07 Bq/kg [(13)].

The aim of the present work is to determine the radioactive content of uranium, thorium, potassium, and Cs fallout in different food samples in order to know the safety of eating such food.

EXPERIMENTAL PROCEDURE

In the present work thirty five samples of different types of food materials were collected from the local markets, these are wheat, flour, popcorn, starch, rice, macaroni, broad beans, dried crushed broad beans, brown lentils, lentils, black eyed peas, termes, small dried chick peas, fish, dried vegetable soup, dried green mallow, chittos, and chippsy. spices group as coriander, two hot red pepper samples, two black pepper samples, cumin, and two salt samples, also powdered milk, chocolate powder, coffee beans, tea, nescafe, erkesous, sugar, black honey and honey.

The solid samples were ground to mesh size 100. For gamma activity analysis 100 cc from each sample were placed in a polyethylene container, these were completely sealed, weighed, and were left for at least one month to allow radioactive equilibrium.

A coaxial hyperpure Ge detector, of volume 76.11 cm^3 with a wide energy range, and the resolution was 1.9 keV at the 1332.5 keV gamma ray transition of ^{60}Co, was used together with the other measuring components in a singles gamma ray spectrometer and a Maestro, II-EG&G ORTEC MCA card mounted on an IBM compatible PC together with simple programs to estimate quantitatively the elements present in the samples under investigation.

The absolute efficiency calibration curve for the spectrometer was carried out together with the energy calibration. To reduce the background the detector was placed surrounded by a lead cylindrical shield lined with a copper layer inside it and covered with a movable cover. The background was monitored to be taken in consideration. The concentrations were calculated using the different gamma transitions of every isotope present for U, Th and the average values are given. Also the concentration of K was calculated.

The gamma spectra, for the different samples were collected for at least twenty-four hours, the back ground was taken in consideration when the quantitative calculations of the uranium, thorium and potassium were made.

RESULTS

The spectrum of one food sample is shown in Figure (1). The average concentration values of U, Th and K calculated using the different gamma transitions of every isotope present are shown in Table

(1) in Bq/kg and ppm. Table (2) shows the concentration of Cs-137 detected in the twelve food samples in Bq/kg.

From the above results it is observed that the uranium concentration varied from 0.48 in sample 31 (nescafe) to (20.74) Bq/kg in sample 6 (dried vegetable soup). The radium concentration varied from less than 2.62 for sample 1 (wheat) to 20.08 Bq/kg in sample 22 (hot red pepper). For thorium the least detected value was 0.27 in sample 28 (chocolate powder) to 7.93 Bq/kg in sample 7 (broad beans). Potassium was observed in most samples, its least value was 3.41 for sample 26 (salt) to 1179.54 Bq/kg in sample 31 (Nescafe).

In the present investigation the least concentration of Cs-137 detected is 0.97 in sample 21 (hot red pepper) to 4.16 Bq/kg for sample 23 (black pepper) and 4.39 Bq/kg for sample 15 (powdered milk).

DISCUSSION

From the present results, one may draw out the following remarks concerning U, Th, K and Cs respectively. **Concerning the uranium content** we can distribute the values in four ranges 13-21, 5-7.5, 0.4-4.5 Bq/kg, and samples in which the uranium was not detected.

In the highest range 13-21 Bq/kg there are two samples, sample 8 (dried crushed broad beans) contains 13.95 Bq/kg and the highest value of uranium was 20.74 Bq/kg in sample 16 (dried vegetable soup).

The second range between 5 and 7.5 Bq/kg includes five samples, samples 27 (salt), 7 (broad beans), 22 (hot red pepper), 10 (lentils) and the highest value of U in this range was 7.15 Bq/kg for sample 19 (chippsy).

The third range between 0.45 to 4.5 Bq/kg included most of the samples (twenty one samples) namely: samples 31 (Nescafe), 25 (cumin), 34 (black honey), 33 (sugar), 26 (salt), 14 (fish), 12 (termes), 1 (wheat), 3 (popcorn), 2 (flour), 28 (chocolate powder), 23 (black pepper), 11 (black eyed peas), 32 (erkesous), 30 (tea), 5 (rice), 17 (dried green mallow), 24 (black pepper), 21 (red hot pepper), 20 (coriander) and sample15 (powdered milk) contains the highest value in this range 4.1 Bq/kg.

Uranium was not detected in the following seven samples namely: samples 4 (starch), 6 (macaroni), 9 (brown lentils), 13 (small dried chick peas), 18 (chittos), 29 (coffee beans) and sample 35 (honey).

On the other hand the Thorium content can be divided into three regions from 3.3 to 8, 0.25 to 3 Bq/kg and was not detected in the third region.

The first region from 3.3 to 8 Bq/kg contains eight samples, samples 5 (Rice), 20 (coriander), 19 (chippsy), 23 and 24 (black pepper), 31 (coffee), 25 (cumin) and the highest value in this region was 7.93 Bq/kg for sample 7 (broad bean).

The second region contains 24 samples and ranged from 0.25 to 3 Bq/kg as follows, chocolate powder, black honey, popcorn, salt (sample 26), macaroni, lentils, honey, erkesous, coffee, hot red pepper (sample 21), dried vegetable soup, brown lentils, wheat, powdered milk, starch, hot red pepper (sample 22), dried green mallow, tea, termas, salt (sample 27), fish, small dried chick peas, broad beans and chittos which has the highest value of Th 2.95 Bq/kg.

The thorium was not detected in the following three samples which are sugar, black eyed peas, and flour.

Concerning the potassium content it was distributed in 6 regions ranging from 900-1180, 430-615, 300-400, 200-280, 3-150 Bq/kg and it was not detected in two samples which are sample 33 (sugar) and sample 4 (starch).

The highest region from 900-1180 Bq/kg, five samples, includes samples 25 (cumin), 22 hot red pepper, 17 (dried green mallow), 21 hot red pepper and sample 31 (nescafe) which contains the highest value 1179.54 Bq/kg.

The second region between 430-615 Bq/kg contains six samples, samples 23 and 24 (black pepper), 30 (tea), 29 (coffee beans), 7 (broad beans) and contains sample 20 (coriander) with potassium content 611.79 Bq/kg.

In the third region which is between 300-400 Bq/kg there are, seven samples, samples 32 erkesous, 9 (brown lentils), 28 (chocolate powder), 15 (powdered milk), 8 (dried crushed broad beans), 14 (fish) and sample 11 (black eyed peas) contains 392.63 Bq/kg.

The fourth region between 200-280 Bq/kg includes four samples which are samples 16 (Dried vegetable soup), 12 (Termas), 13 (Small dried chick peas), and sample 10 (Lentils) contains 277.2 Bq/kg.

The region from 3-140 Bq/kg contains, eleven samples, samples 26 & 27 (Salt), 2 (flour), 5 (rice), 35 (honey), 19 (chippsy), 6 (macaroni), 18 (chitos), 3 (popcorn), 34 (black honey) and 1 (wheat) which contains the maximum value in this region 135.93 Bq/kg.

It is observed that the U, Th and K content differ in the two salt samples (0.94, 0.64 and 3.41) Bq/kg for sample 26 and (5.1, 5.66 and 26.66) Bq/kg for sample 27; this could be due to different origin sources of the two samples.

It is also observed that the Starch sample did not contain U or K and the sugar sample did not contain Th or K.

In the present investigation Cs -137 was observed in twelve samples divided in two ranges 3.2-4.5 and from 0.9 to 3 Bq/kg. Samples 24 and 23 (black pepper) are in the highest detected region and sample 15 (powdered milk) contains 4.39 Bq/kg.

The second region from 0.9-2.8 Bq/kg contains the samples 21 (hot red pepper), 28 (chocolate powder), 29 (coffee beans), 30 (tea), 17 (dried green mallow), 12 (termes), 31 (nescafe), 5 (rice) and sample 22 (hot red pepper) contained 2.97 Bq/kg.

The Cs is mostly observed in most of the spices samples also in chocolate powder, coffee beans, tea and nescafe in addition to rice, termes and dried green mallow while the maximum value was in the powdered milk sample.

The difference in U, Th, K and Cs contents in the studied samples may be due to different origins, either imported or local origins.

From the above discussion, it is concluded that it is safe to eat the above samples yet the accumulation of large amounts may produce high doses of radiation to man. It is recommended that Cs-137 contaminated samples must be sent to laboratories equipped to analyze the samples, periodic monitoring is needed to establish baseline levels in the various food products.

Table (1) Concentrations of U, Th and K for food samples

Sample No.	Sample	U Bq/kg	Th Bq/kg	K Bq/kg	U ppm	Th ppm	K ppm
1	Wheat	1.93	2.21	135.93	0.16	0.55	4.27
2	Flour	2.34	*	28.43	0.19	0.00	0.89
3	Popcorn	2.02	0.61	99.95	0.16	0.15	3.14
4	Starch	*	2.38	*	*	0.59	*
5	Rice	2.88	3.32	33.83	0.23	0.82	1.06
6	Macaroni	*	0.89	37.84	0.00	0.22	1.19
7	Broad beans	6.10	7.93	596.82	0.49	1.96	18.77
8	Dried crushed broad beans	13.95	2.82	372.40	1.13	0.70	11.71
9	Brown lentils	*	1.88	302.43	0.00	0.47	9.51
10	Lentils	6.91	0.93	277.20	0.56	0.23	8.72
11	Black eyed peas	2.71	*	392.63	0.22	0.00	12.35
12	Termes	1.62	2.62	261.31	0.13	0.65	8.22
13	Small dried chick peas	*	2.78	271.21	0.00	0.69	8.53
14	Fish	1.35	2.73	389.51	0.11	0.68	12.25
15	Powdered milk	4.10	2.36	352.63	0.33	0.58	11.09
16	Dried vegetable soup	20.74	1.84	205.06	1.67	0.46	6.45
17	Dried green mallow	2.95	2.54	978.34	0.24	0.63	30.77
18	Chittos	*	2.95	87.29	0.00	0.73	2.75
19	Chippsy	7.15	3.75	37.40	0.58	0.93	1.18
20	Coriander	3.43	3.49	611.79	0.28	0.86	19.24
21	Hot red pepper	3.14	1.55	991.81	0.25	0.38	31.19
22	Hot red pepper	6.54	2.47	939.80	0.53	0.61	29.55
23	Black pepper	2.64	4.47	431.76	0.21	1.11	13.58
24	Black pepper	3.38	4.63	507.85	0.27	1.15	15.97
25	Cumin	0.67	5.58	900.58	0.05	1.38	28.32
26	Salt	0.94	0.64	3.41	0.08	0.16	0.11
27	Salt	5.10	2.67	26.66	0.51	0.66	0.84
28	Chocolate powder	2.44	0.27	322.96	0.20	0.07	10.16
29	Coffee beans	*	1.54	591.75	0.00	0.38	18.61
30	Tea	2.88	2.61	559.99	0.23	0.65	17.61
31	Nescafe	0.48	5.55	1179.54	0.04	1.37	37.09
32	Erkesous	2.81	1.54	300.62	0.23	0.38	9.45
33	Sugar	0.85	*	*	0.07	*	*

34	Black honey	0.76	0.40	117.63	0.06	0.10	3.70

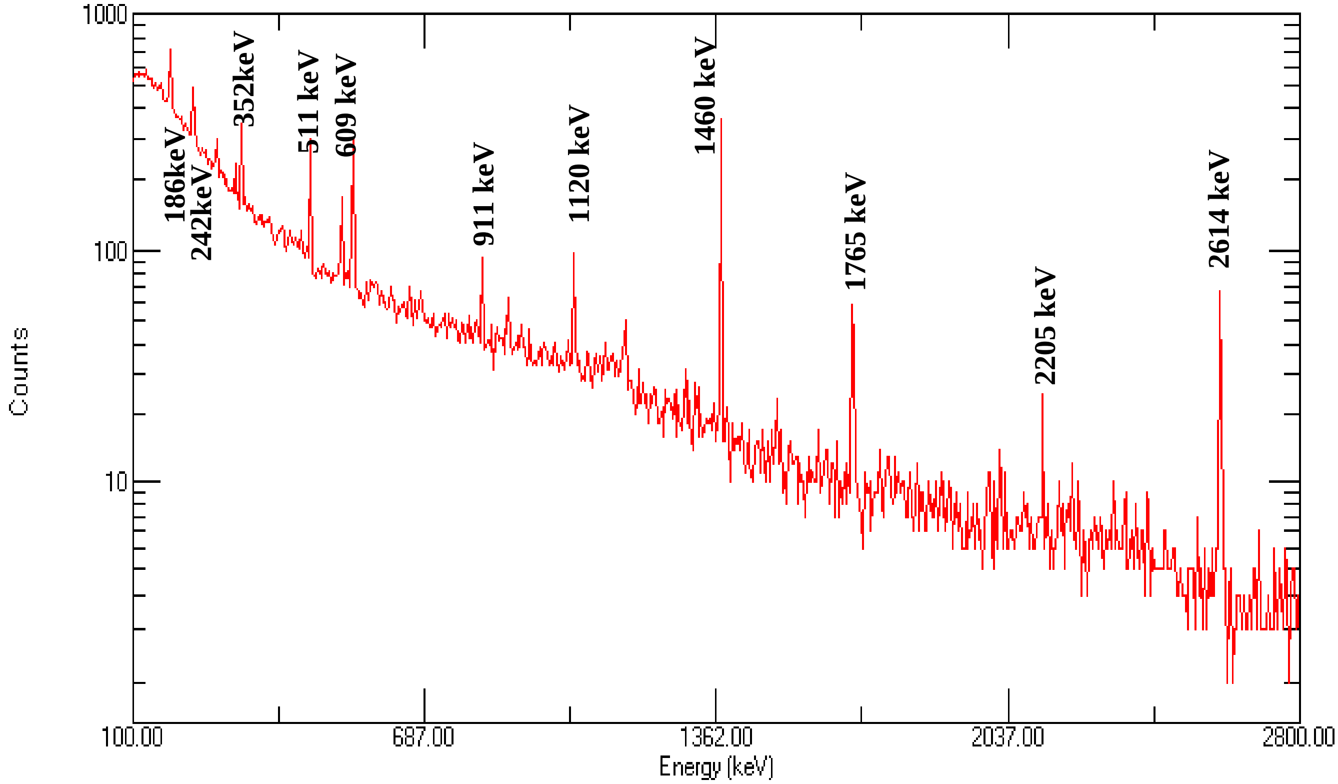

Fig. (1): Spectrum for a food sample number 17

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