Radionuclides Activity and Radiological Hazard Assessment in samples of potato chips by using a High Purity Germanium (HPGe) detector

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Abstract

The average concentration of radionuclide's in the various potato chips samples were collected from being the most popular markets in Baghdad city - Iraq were measured by use a High Purity Germanium (HPGe) detector. The radionuclide's observed with reliable regularity belonged to the series-decay naturally occurring radionuclide's headed by ^{238}U and ^{232}Th as well as the non-series nuclide, ^{40}K. The average concentration of ^{238}U was found the least average concentration value recorded as 0.71 Bq kg^{-1} .The average concentration of ^{40}K was 68.22 Bq kg^{-1} For ^{232}Th, it was found to have the average concentration 2.06 Bq kg^{-1} . also was calcualed radium equivalent activity (*Raeq*), internal hazard index (Hin), external hazard index (H_{ex}) *and* the annual effective dose(*D*) for each sample . It was observed that none of the above treatments exceeded the recommended values globally.

Keyword: Radioactivity, specific activity, ^{234}U, ^{232}Th, ^{40}K, HPGe

Introduction:

The Radionuclides and their decay products from ^{238}U and ^{232}Th series together with ^{40}K are terrestrial primordial radionuclides, which originated from the earth's crust and are the sources of natural radioactivity in the environment .[1] The long-lived radioisotopes uranium ^{238}U ($t_{1/2}$ =4.47×10 y), ^{232}Th ($t_{1/2}$=1.4×10 y), and ^{40}K ($t_{1/2}$=1.25×10 y) and their daughter nuclides do present naturally in all ground formations. Nuclear technologies and industrial products and by-products may add more to the terrestrial radiations, making the earth a source of background radiations where all living creatures are exposed to and subject to their absorption consequences. It is an established fact that radioactivity might be transferred to human beings through the food chain.[2,3] The study of the radioactivity concentration in plants in the environment are of interest within ecological and plant evolution under certain conditions of geochemical point of view and adaptation, and it

thus provide information in the monitoring of environmental radioactivity.[4,5] Therefore, studies and radiological surveys of air, soil, rocks, water, heavy water, food, vegetables, etc. have increased to measure the level of radiation doses to which humans are exposed. [6-11] In addition, a large portion of the annual effective dose due to natural sources is caused by the intake of foods .[12] Plants are the primary recipients of radioactive contamination in a food chain. Vegetation may be subject to direct and indirect contamination. The direct contamination of terrestrial vegetation refers to the deposition of radioactive materials from the atmosphere onto the parts of plants above ground . [13, 14] Indirect contamination refers to the absorption of radionuclides from the soil by the root system of plants.[15]
This study investigated the activity concentration of ^{234}U, ^{232}Th and ^{40}K in some chips species and its popularly consumed in Baghdad city, Iraq, in order to improve the understanding on the effects on peoples. The radium equivalent, the external hazard index, the absorbed dose and the annual effective dose were assessed and compared with results of the worldwide average value in the United Nations Scientific Committee on the Effects of Atomic Radiation report [16].

Material and Methods

Six samples of different types of potato chips were collected from different markets in Baghdad city. A total samples were collected as 3 samples from each exported country (Saudi Arabia, Jordan, Iran)
And 3 samples from (Iraq, Erbil).The samples are then grinded to powder at a rate of one kilogram per sample and sealed in airtight plastic container. The samples were thereafter left for 28 days in order for gaseous daughters of ^{238}U, ^{232}Th *and* ^{40}K to reach secular equilibrium before counting was taken [17].
Gamma-ray spectroscopic system detects gammas emitted from sample materials using a High Purity Germanium (HPGe) detector [18]. As radioactive isotopes emit gammas of intrinsic energy, if we measure the energy of gammas, we can tell apart the kind of isotope and its activity. Gamma-ray spectroscopic system is used to identify the isotopes and activities by measuring gammas from a sample material. Most of (HPGe) detectors use high-density and high atomic numbered lead as a shield to reduce background noise due to radiation and radioactive dirt existing around the detectors.(HPGe) gamma-ray spectrometers are used widely for the measurement of environment radiations[19].

Results and Discussion:

Activity Concentration

The activity concentrations in ($Bq.kg^{-1}$) for the six studied samples calculated for each of the ^{238}U,^{232}Th and ^{40}K radionuclide's by using eq's. [20].

$$A_s = \frac{A}{W}(Bq.kg^{-1})$$

Where *A* is the activity of the isotope, *W* is the weight of the sample
In table (1), The activity concentration of ^{40}K ranged from 254.1 (Bg / Kg) in chips Lays (Saudi Arabia) to 7.99 (Bg / Kg) in Chips Pato (Iran). The highest activity concentration of ^{238}U was found in Chips Tycoon (Erbil) 1.31 (Bg / Kg), while the lowest concentration was found in Chips Pato (Iran) 0.14 (Bg / Kg) . The activity concentration of ^{232}Th have values in chips Lays (Saudi Arabia) is 10 Bq/kg and 2.4 (Bg / Kg) in Chips Pato (Iran). Same results were found in the shells of samples where it found for ^{40}K to be the highest in all the samples. However, the values obtained for ^{40}K were very low compared to values obtained for other locally produced food stuffs in the area. Since the values obtained for ^{40}K were almost within the same range in all the samples, this could put the source of ^{40}K as being from samples of the potassium rich. The mean activity concentrations of ^{40}K and ^{232}Th were found to be high in 68.22 Bq/kg and 2.09Bq/kg respectively, while the lowest concentration rate of ^{238}U 0.71(Bg / Kg).

Calculation of Radiological Effects

To represent the activity levels of ^{226}Ra, ^{232}Th and ^{40}K by a single quantity, which takes into account the radiation hazards associated with them, a common radiological index has been introduced called radium equivalent activity (*Raeq*) in $Bq.kg^{-1}$ to compare the specific activity of materials containing different amounts of ^{226}Ra,^{232}Th and ^{40}K [21]:

$$Ra_{eq} = C_{Ra} + 1.43C_{Th} + 0.077C_K$$

where, C_{Ra}, C_{Th} and C_K are the specific activities of ^{226}Ra ^{232}Th and ^{40}K respectively According to Table (2) note that uranium equivalent were found out by the equation number. (4) It was noted that the overall rate her is 8.91 (Bg / Kg) and the highest value of the equivalent 34.26 (Bg / Kg) in chips Lays (Saudi Arabia) and the lowest value Chips in Chipsico (Jordan) 0.74 (Bg / Kg) according to figure (1).

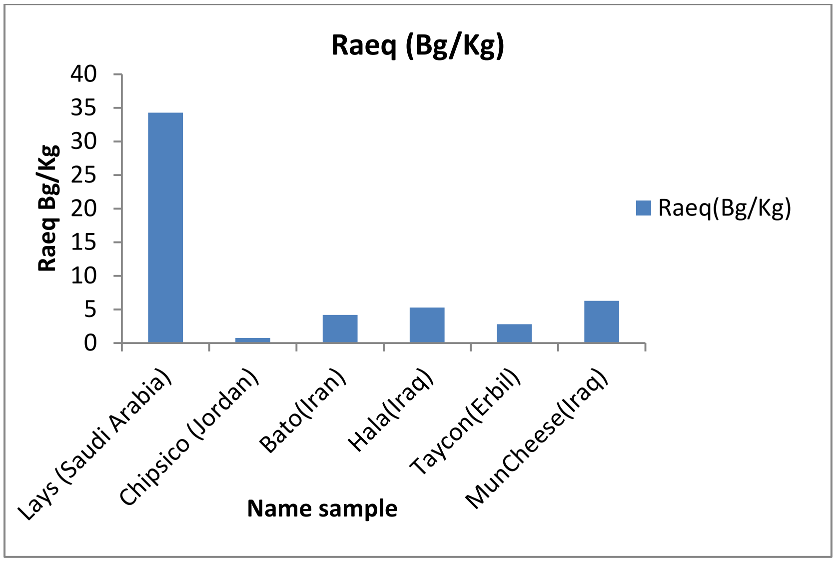

Fig.1: Radium equivalent activity.

A widely used hazard index (reflecting the external exposure) called the external hazard index is defined as follows [2]:

$$H_{ex} = \frac{C_{Ra}}{370} + \frac{C_{Th}}{259} + \frac{C_K}{4810}$$

he calculated values of H_{ex} (Table 2) for samples were the highest value is 0.09 in chips Lays (Saudi Arabia) and The minimum value of 0.002 in chips Chipsico (Jordan)(means is 0.02) . according to Figure (2).

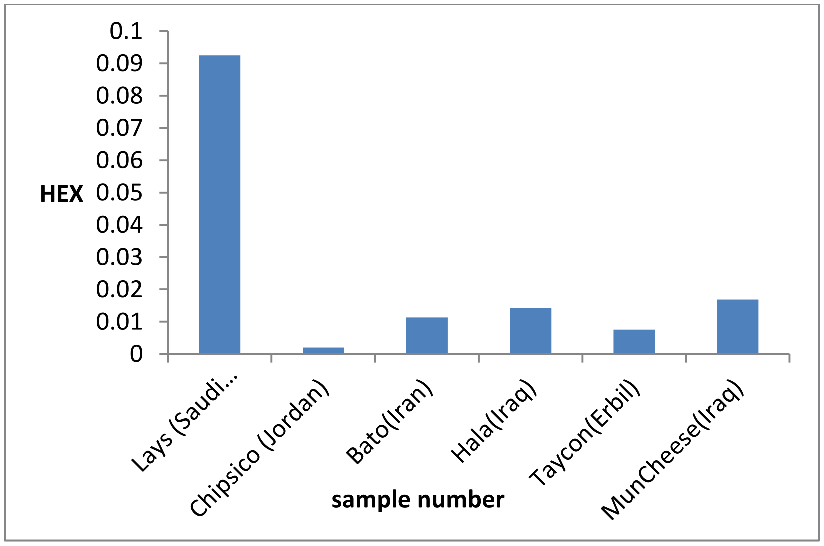

Fig. 2: External Hazard Index

For the internal hazard index (Hin) [22]:

$$H_{in} = \frac{C_{Ra}}{185} + \frac{C_{Yh}}{259} + \frac{C_K}{4.810}$$

The average values for samples were 0.02 and and it was the highest value is 0.09 in Chips Lays (Saudi Arabia) and The minimum value is 0.004 in chips Chipsico (Jordan) . according to figure (3).

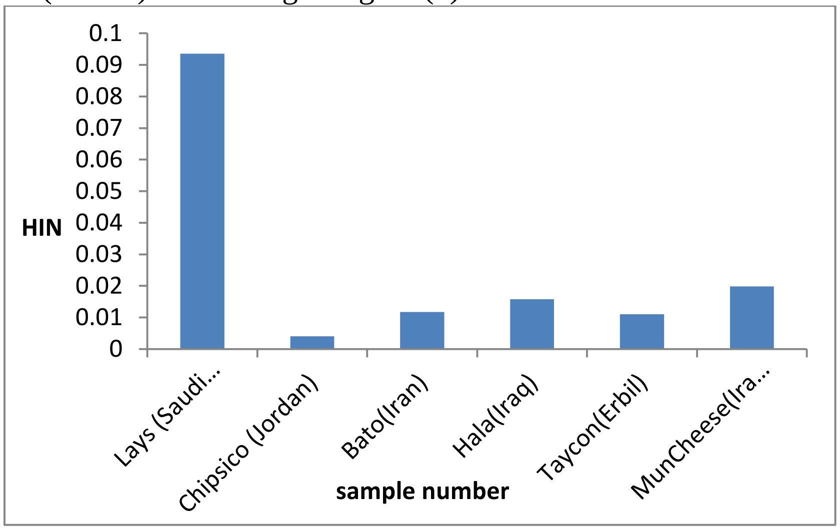

Fig. 3: Internal Hazard Index

The absorbed dose rates (*D*) due to gamma radiations in air at 1m above the ground surface for the uniform distribution of the naturally occurring radionuclides (^{226}Ra, ^{232}Th and ^{40}K) were calculated based on guidelines provided by UNSCEAR 2000 [2]. The outdoor dose (D_{out}) was calculated:

$$D_{out} = 0.462C_{Ra} + 0.604C_{Th} + 0.0417C_K$$

The average values for samples were 4.45 nGy h^{-1}

Where the overall rate is 4.45(nGy h^{-1}) and was the highest value is 16.99(nGy h^{-1})in Chips Lays (Saudi Arabia) and The lower value is 0.34(nGy h^{-1}) in Chips chipsico (Jordan) .

The indoor absorbed dose rate (D_{in}) was calculated using the equation [22]:

$$D_{in} = 0.92C_{Ra} + 1.1C_{Th} + 0.08C_K$$

The average values of D_{in} for samples were 8.54 (nGy h^{-1})

The annual effective dose was calculated in terms of outdoor (E_{out}) and indoor (E_{in}), respectively. The conversion factor (0.7 Sv Gy^{-1}) and (0.2) (0.8) outdoor and indoor occupancy factors, respectively, were used to estimate E_{out} and E_{in} [22]

$$E_{outdoor} = observed\ dose\ [G_y / h] \times 8766\ h/y \times 0.7\ [\text{Sy/Gy}] \times 0.2 \times 10^{-6}$$

$$E_{intdoor} = observed\ dose\ [G_y / h] \times 8766\ h / y\ \times\ 0.7\ [\text{Sy/Gy}]\ \times\ 0.8 \times 10^{-6}$$

where 8766 h y^{-1} is number of hours in one year (leap year was taken in account), and 10^{-6} is the conversion factor between nano and milli.

The results obtained for E_{out} and E_{in} are shown (Table 2).The average values of E_{out} and E_{in} for samples were 0.005 and 0.02 , respectively.

These values were less than the lower limit of 20 mSv y^{-1} for radiation workers and even lower than the recommended level of 1 mSv y^{-1} for the general population (ICRP, 1991) [12].

Another radiation hazard index, the representative level index, $I_{\gamma r}$, used to estimate the level of γ-radiation hazard associated with the natural radionuclides in investigated samples, to examine whether the samples meets these limits of dose criteria. It defined as [20]:

$$I_{\gamma r} = \frac{C_{Ra}}{150} + \frac{C_{Th}}{100} + \frac{C_K}{1500}$$

Where the overall rate is her 0.07 (Bg / Kg) and was the highest value is 0.04 (Bg / Kg) in chips Lays (Saudi Arabia) and The lower value is 0.02(Bg / Kg) in Chips Hbsako (Jordan)

According to Figure (5)

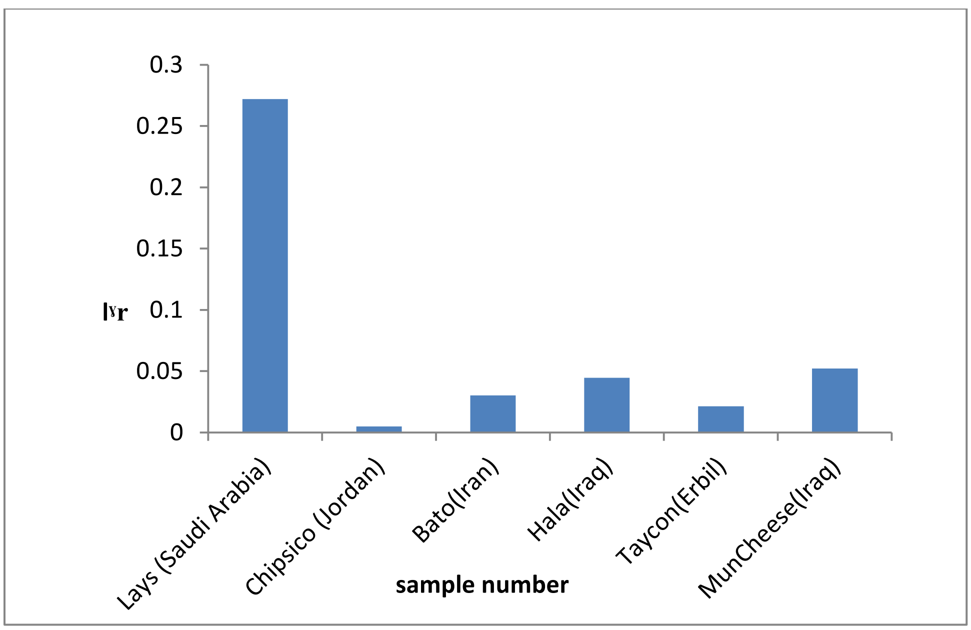

Fig.5: Representative gamma index.

Table 1: Activity concentration of radionuclide

Sample Number	Sample name	Activity concentration (Bq/kg)		
		^{232}Th	^{234}U	^{40}K
1	Lays(Saudi Arabia)	10	0.4	254.1
2	Chipsico(Jordan)	0	0.74	0
3	Bato(Iran)	2.4	0.14	7.99
4	Hala(Iraq)	0	0.58	61
5	Taycon(Erbil)	0	1.31	19.1
6	MunCheese(Iraq)	0	1.09	67.13
Average		2.06	0.71	68.22

Table 2: The hazard indices

Sample Number	sample name	Ra_{eq} (Bq/Kg)	H_{ex}	H_{in}	D_{out}(nGy/h)	D_{in}(nGy/h)	Eout	Ein	Iγr
1	Lays (Saudi Arabia)	34.26	0.092	0.093	16.99	32.496	0.020	0.08	0.04
2	Chipsico (Jordan)	0.74	0.002	0.004	0.34	0.6808	0.0004	0.001	0.02
3	Bato(iran)	4.18	0.0113	0.0116	1.88	3.6	0.002	0.009	0.05
4	Hala(iraq)	5.27	0.014	0.015	2.81	5.4136	0.003	0.01	0.27
5	Taycon(arbil)	2.78	0.007	0.011	1.40	2.7332	0.001	0.006	0.004
6	MunCheese(Iraq)	6.25	0.016	0.019	3.301	6.3732	0.004	0.016	0.03
Average		8.91	0.024	0.026	4.45	8.549467	0.005	0.02	0.07

Conclusions

In this work has been the activity concentration of U-238, Th-232 and K-40 present in most of the studied are relatively lower that the average of worldwide concentration as it acceptable dose limits of both the UNSCEAR (1988) and the ICRP (1991)[16,17]. With this, we recommend that the measurement is repeated to determine more than the samples with relatively high concentration in addition to what already has been calculated coefficients of both radium and external and internal risks of radiation equivalent, as well as affecting the rights of radioactive elements normal dose has been observed that any of the above-mentioned transactions did not exceed much values recommended globally.

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