Investigating Radioactive Content in Various Commercially available Flour Samples in Local Iraqi Markets

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Abstract

The study was conducted to assess the radioactivity of alpha concentration of different samples of flour in Karbala mills and some samples in local Iraqi markets. Alpha sensitive CR-39 plastic paths detectors commonly know as "Solid State Nuclear paths Detectors" were used measuring the concentrations of uranium, efficaious radium content, and ratio of radon. The results indicate that the exhalation levels of mass and surface radon were between 0.214-0.549 mBq/kg.h, and 4.35 -11.185 mBq/m^2.h, respectively, with an mediam of 0.385 mBq/kg.h and 7.691 mBq/m^2.h. The effective radium content values range from 28 to 78 mBq/kg with an mediam value of 51.06 mBq/kg, respectively. The concentration of uranium values ranges from 0.334 to 0.858 Bq/kg, with a mean value of 0.602 Bq/kg. The measurements of the radon, radium, and uranium concentration in each sample are significant in terms of health safeguard point of view. Hence, easy, and accurate techniques of analysis are highly demanded.

Key Words: Natural Radioactivity, Alpha Particles, CR-39, Flour, Iraqi Market.

DOI Number: 10.14704/nq.2021.19.9.NQ21131 **NeuroQuantology 2021; 19(9):06-13**

Introduction

Earth is a naturally radioactive planet, nearly 80% of the overall dosage taked by humans is essentially from naturalistic radiation sources, including inner radiation, and radon (Schauer, 2009). Radon (^{222}Rn) is a radiant idle gas that originated from radium dissolution in the naturally eventting uranium string (^{238}U). It accounts for around bisection of the radiation dosage obtained by the general public (UNSCEAR, 1994). Radon atoms are continually formed in all-natural soils within the α-decay chains of uranium (^{238}U) and thorium (^{232}Th). A fraction of these emanate from the soil's air-filled cracks and gradually exit into the atmosphere (Nazaroff, 1992). When present in ambient air, radon and its daughter progeny linked to air dust constitute a substantial radioactive threat to human lung (Hopke, 1987, Council, 1999). Radon offspring collects in the lung during respiration and thus irradiating the tissues which damages the cells and can procure lungs cancer (Al-Zoughool and Krewski, 2009; Vogeltanz-Holm and Schwartz, 2018). It was annunciatted that indoor radon exposure was related with the hazard of leukemia and some other cancers, such as melanoma, kidney, and prostate cancers. The concentration of radon and its products for decay demonstrates significant temporal and local changes in the indoor environment due to temperature variability, heat, design of construction materials, airflow requirements, and wind velocity, etc.

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Received: 24 June 2021 **Accepted:** 02 August 2021

Radiological risks as a consequence of inner radiation exposure have resulted to globular efforts by organizations toexecution necessary steps in the process of investigating and abating the ingestion of radionuclides in foodstuffs. Thus, protecting consumers from potential genetic diseases and cancers caused by radiation exposure (Ishigure et al., 2004; Unscear, 2000). For the detection of charged particles, solid-state nuclear path detectors are widely employed in a variety of technology applications (Durrani and Bull, 2013; Nikezic and Reports, 2004). The nuclear path detectors have a rational resolve of particle charge and energy. This makes them suitable for more sophisticated particle physics studies. Depending on radon concentration and radium content in different drinking samples from local Iraqi marketplaces, we assessed the responsiveness of two widely used detectors in Iraq namely CR-39 and CN-85. (Hashima et al., 2021). Herein, this study aims to estimate the rate of surface and mass exhalation of radon gas besides the effective radium content and uranium concentrations present in different sixteen samples of flour in Karbala mills and some samples in the national Iraqi markets. Flour is one of the essential foods that is consumed routinely in Iraqis daily lives. Therefore, it is necessary to monitor such commodities to ensure the necessary prevention for Iraqi consumers from any radiological hazards that may be associated with them.

Experiment and Method

In the present study, the "sealed can technique" has been used for the determination of alpha radioactivity in various samples of flour from Karbala mills and others from the local Iraqi market (Kumar et al., 2005). The experimental set-up is shown in **Figure 1**. Solid State Nuclear Track Detectors (SSNTD) known as CR-39 were used in this study with a sheet thickness of 500 μm (Somogyi G, 1986). A dried and sieved sample from each of the collected ones (40 g) was placed at the bottom of a cylindrical sealed can of 7 cm height and 5 cm diameter. The opening of the cylindrical can was sealed with a cover and fitted with CR-39 plastic track detectors (1 cm ×1 cm) at the top inner surface. The detector register the paths of α-particles released from radon gas created by the α-decaying of the samples' radium concentration. For around 72 days, the detectors were revealed. The detectors were collected after exposures and scraped for six hours in a 6.25N NaOH solution kept at (70 ± 1) °C in a fixed temperature water bath to show the paths. The detectors had to be cleaned and completely dried. Following that, α-paths were computated using a 400X resolution light microscopy (40X objective and 10X lens) (kruss, 2000). The samples are listed in **Table 1**.

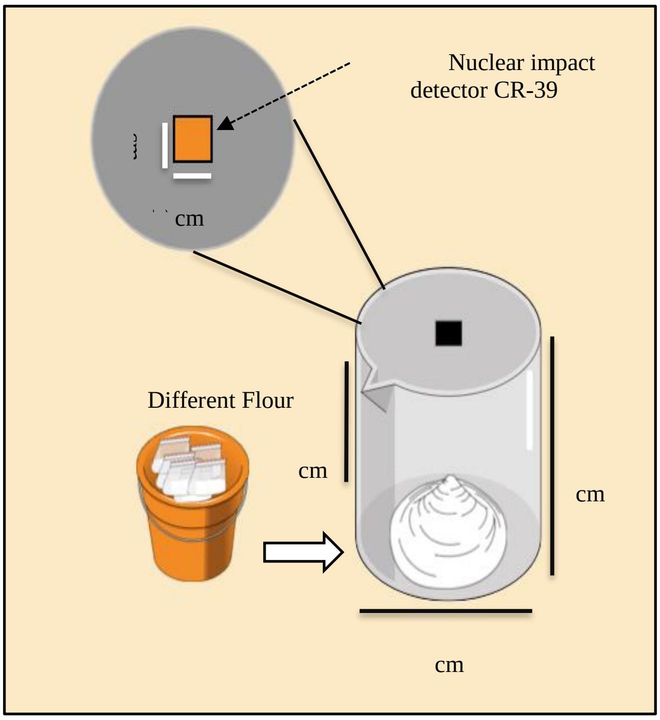

Figure 1. Schematic illustration of the sealed-can technique used in this study.

Table 1. Sample identifications and designating codes of various flour samples used in the study.

Sample identification	Code
Al-Zuhairy Mill	**S1**
Alalaq Mill	**S2**
Hanaa Mill	**S3**
Al Hussein Mill	**S4**
Abu Tamma-m Mill	**S5**
Ambassador Mill	**S6**
Al-Rawda Mill	**S7**
Al-Ali Mill	**S8**
Karbala Mill	**S9**
Loyalty Mill	**S10**
Al-Hadi Mill, Baghdad	**S11**
Al Manar Hillah Mill	**S12**
Kuwaiti flour	**S13**
Iranian flour	**S14**
Turkish flour	**S15**
Turkish flour for sammon furnaces	**S16**

Nuclear paths density on the superficies of the CR-39 alpha particle detectors was term as the proportion between the total number of nuclear paths on the detectors surfaces and the region of vision of the light microscope used for computated the nuclear paths on the detector surface linked with alpha particles, as shown below (Ahmad et al., 2014):

$$Track\ density\ (\rho) = \frac{\sum N_i}{nA} \qquad (1)$$

where A refers to the view section area, N_i denotes the total number of nuclear paths, and n signifies the number of microscopic observations on the surface of the detector. The radon activity density C_a in the can air above the sample was computed by taking the density of the paths on the detector using the equation below, Hashim and Mohammed, 2016:

$$C_a = \frac{\rho}{KT} \qquad (2)$$

Where ρ is the gauged surface density of paths on the uncovered detectors (Track/cm2), T is the exposures time, K is the calibration factor. Using a calibration factor, the routes densities were linked to the radon concentration plane of 0.223Track.cm^{-1}.day^{-1} /Bq.m^{-3} (Hashim and Mohammed, 2016).

radon concentration (C_{Rn}) in a samples may be articulated in terms of radon concentration released into the surrounding air, As shown below (Abdullah, 2012):

$$C_{Rn} = C_a\left(\frac{\lambda.h.T}{L}\right) \qquad (3)$$

Where C_a denotes the concentration of radon in the air above the sample (Bq/m^3), λ denotes radon decomposition equal to 0.1814 day^{-1}, h is The distance between both the samples surfaces and the detectors , T, Time exposing the detector to sample in days, L: Height of the sample inside the can (cm).

The effective radium content of the samples can be calculated using the following equations (Ali et al., 2013; Mahur et al., 2008; Mahur et al., 2008):

$$C_{Ra}(Bq.kg^{-1}) = \left(\frac{\rho}{KT_e}\right)\left(\frac{hA}{M}\right) \qquad (4)$$

Where M is the sample's weight in kilograms, A is the can's cross-sectional area in square meter, and h is the distance between the detector and the top layer of the samples in meter. Te indicates the effective exposure time as determined by (Azam et al., 1995):

$$\mathrm{T_e} = [\mathrm{T} - \lambda_{\mathrm{Rn}}^{-1}(1 - \mathrm{e}^{-\lambda_{\mathrm{Rn}}\mathrm{T}})] \qquad (5)$$

the surface exhale ratio of the sample for release radon may be determined, by the equation (Khan et al., (1992); Al-saadi et al., 2013):

$$\mathrm{E_S}(\mathrm{mBq\ m^{-2}h^{-1}}) = \frac{\mathrm{CV\lambda}}{\mathrm{A[T+\lambda^{-1}(e^{-\lambda T}-1)]}} \ (6)$$

Where, Es denotes the radon exhale ratio in term of region expressed in (mBqm^{-2}h^{-1}), C refers the integral radon exposure in Bq m^{-3}h, V is the sample's efficient size in m^3, The exposure duration in hour is denoted by T, λ is the disintegration constant for ^{222}Rn radon (h^{-1}), and A is the area of sample (m^2). Using the expressing, the mass expiratory ratio of the sample for radon launch can be computed (Khan et al., (1992); Al-saadi et al., 2013):

$$\mathrm{E_M}(\mathrm{mBq\ kg^{-1}h^{-1}}) = \frac{\mathrm{CV\lambda}}{\mathrm{M[T+\lambda^{-1}(e^{-\lambda T}-1)]}} \ (7)$$

Where, E_m indicates the radon exhale ratio from mass expressed in (mBq.kg^{-1}h^{-1}) and M is the mass of the sample in terms of kg. To find uranium concentrations (C_U)in units of part per million using the following equation (Al-saadi et al., 2013):

$$C_U\ (ppm) = \frac{W_U}{W_s} \qquad (8)$$

Ws is the sample weight, and W_U is the uranium mass in the sample which can calculate from the next equation (Richard Tykva and Josef Sabol, 1995):

$$W_U\ (gm) = \frac{N_U\, W_{mol.}}{N_{Av.}} \qquad (9)$$

Where W_{mol} is weight molecular uranium, and N_U is the number of uranium atoms.

$N_{Av.:}$ Avogadro number 6.023×10^{23}atom/mol.

The quantum of Uranium is usually given in Becquerel per unit mass for ecological radioactivity measure.

Results and Discussion

The results of radon exhale ratio, effective radium content, and uranium concentrations in sixteen different samples of flour in Karbala mills and some samples in the local Iraqi markets were analyzed using sealed can technique are as shown in Table 2. The current study showed the radium production rate within the range of 28-73 mBq/kg with an meddle value of 51.06 mBq/kg. The mass exhalation rates ranged from 0.214-0.549 mBq/kg.h with an average value of 0.385 mBq/kg.h, while surface exhale ratio ranged from 4.35-11.185 mBq/m2.h with an average value of 7.691 mBq/m2.h. The highest concentration of uranium was observed in Turkish flour was 0.858 Bq/kg while the less concentration of uranium was found in Karbala Mill was 0.334 Bq/kg with an mediam value of 0.602 Bq/kg.

Table 2. The results of path density, radon concentration, effective Radium content, mass and surface exhale ratio, uranium concentration for various flour samples with the minimum, maximum and average values

Code	ρ Track/ cm^2	C_a Bq/m^3	C_w Bq/m^3	C_{Ra} mBq/kg	E_M mBq/kg. h	E_S mBq/m^2.h	C_U Bq/Kg
S1	671.783	41.840	409.848	67	0.504	10.274	0.788
S2	433.409	26.994	264.418	43	0.325	6.628	0.508
S3	373.815	23.282	228.061	37	0.281	5.717	0.439
S4	463.205	28.849	282.597	46	0.348	7.084	0.543
S5	493.002	30.705	300.776	49	0.370	7.540	0.578
S6	344.018	21.426	209.882	34	0.258	5.261	0.404
S7	701.580	43.696	428.027	70	0.527	10.730	0.823
S8	403.612	25.138	246.239	40	0.303	6.173	0.474
S9	284.424	17.715	173.524	28	0.214	4.350	0.334
S10	522.799	32.561	318.954	52	0.392	7.995	0.613
S11	641.986	39.984	391.669	64	0.482	9.818	0.753
S12	612.190	38.128	373.491	61	0.460	9.362	0.718
S13	552.596	34.417	391.669	64	0.482	9.818	0.753
S14	582.393	36.273	355.312	58	0.437	8.907	0.683
S15	731.377	45.552	446.206	73	0.549	11.185	0.858
S16	314.221	19.570	191.703	31	0.236	4.806	0.369
Minimum	284.424	17.715	173.524	28	0.214	4.35	0.334
Maximum	731.377	45.552	446.206	73	0.549	11.185	0.858
Average	507.900	31.633	313.273	51.06	0.385	7.691	0.602

Figure 2 illustrate the dispensation of radium content in the measured samples of flour, The difference in radium concentrations among the flour samples may be noticed in this figure. This difference may be arising becauce to the various in the nature of the sample and nuclei content of this sample. Other reasons for the disparity radium concentrations in the samples of this study is the type and nature of this soil for flour-producing countries as well as the type and quantity of chemical fertilizers used in agriculture and grain production in those countries. In addition to the above reasons, the use of insecticides to deal with pests and diseases, and type of the quantities used are influential factors in increased concentrations of radioactive nuclei in all agricultural plants.

The concentrations of radium in this study are lower than the concentrations of radium in grain-producing countries, especially in the USA, Poland, Romania, Germany and the United Kingdom (UNSCEAR, 2000). These concentrations were higher than the concentrations of radium in China and Japan for the same products (UNSCEAR, 2000). The results for the uranium concentrations in flouer samples were well below the allowed limit 11.7 ppm(144.49 Bq/kg) (United Nations, 1993).

while Figures 3 and 4 indicate a close association between radium production and exhale rate of radon in various flour samples ($R^2 = 1$). This shows a line relation between efficient radium content and the exhale ratio of radon. Figure 5 shows the connection between the effective radium content and uranium concentration in the samples. The findings of this study are consistent with other reported Iraqi studies of different food products such as cereals, legumes, rice, vegetables, tea, biscuit, coffee, edible oils and chips (Hashim and Najam, 2015; Hashim et al., 2015; Hashim et al., 2015; Hashim et al., 2019; Hashim et al., 2019; Hameed et al., 2020; Hashim and Majeed, 2020; Hashim et al., 2019). After that and through the results we have obtained it can be argued that the concentration of uranium, radium and radon exhale ratio in samples in this study does not pose a threat to human life and health. The disparity of concentrations of uranium, radium and radon flux in the samples that have been studied is due to the differ of samples and the type of soil that has the cultivation of these products. In addition, to the type and quantity of chemical fertilizers added to the soil when planting different crops. Other causes are the amount of pesticides used and the kind of treatment of diseases and injuries suffered by crops during their growth period. To limit and reduce the risk of radiation resulting from cereal and legumes, we recommend the following steps: (1) Measuring the radioactivity of the soil before planting to make sure that the type and concentration in the soil that radioactive elements. (2) The use of modern techniques in agriculture through seed laboratory examination to make sure that they are free from radioactive elements which affect the health of humans and animals together. (3)Choose the appropriate chemical fertilizers and which not to cause increase of pollutants in soil and crops produced. (4)Optimum use of agricultural pesticides to combat insects and disease injuries suffered by field crops. (5) Furthermore, the creation of soil and plowed by the occasion and exposure to sunlight period of time leads to the evaporation of some radioactive elements and escaping from the soil, especially radon. We deduce from this research, and after comparing the results with uranium and radium concentrations in some countries of the world, that the results in this research is not dangerous to the life human.

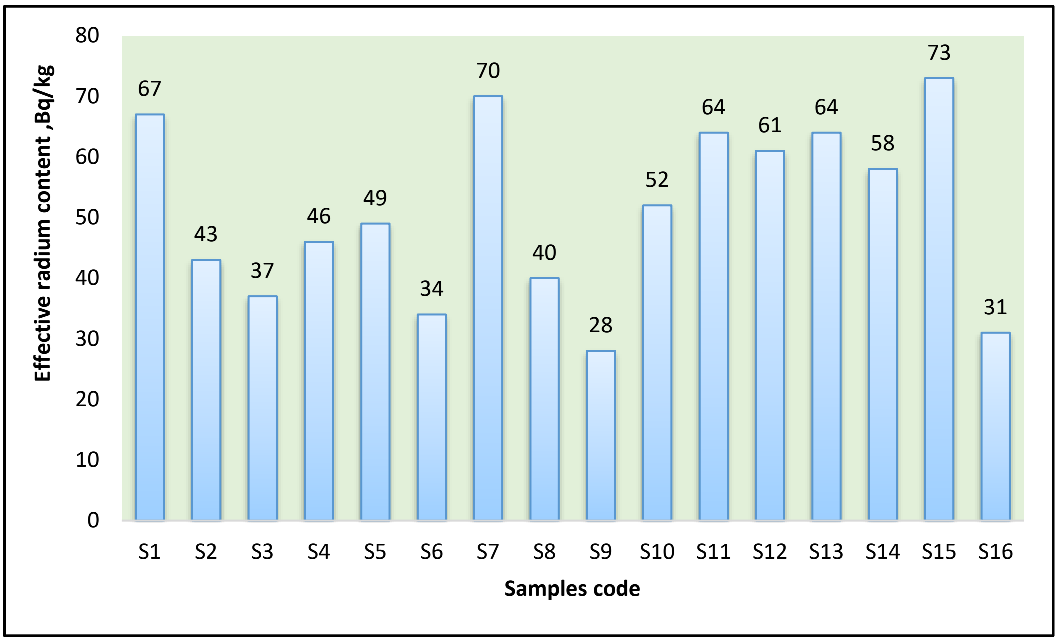

Figure 2. Effective radium content in flour samples

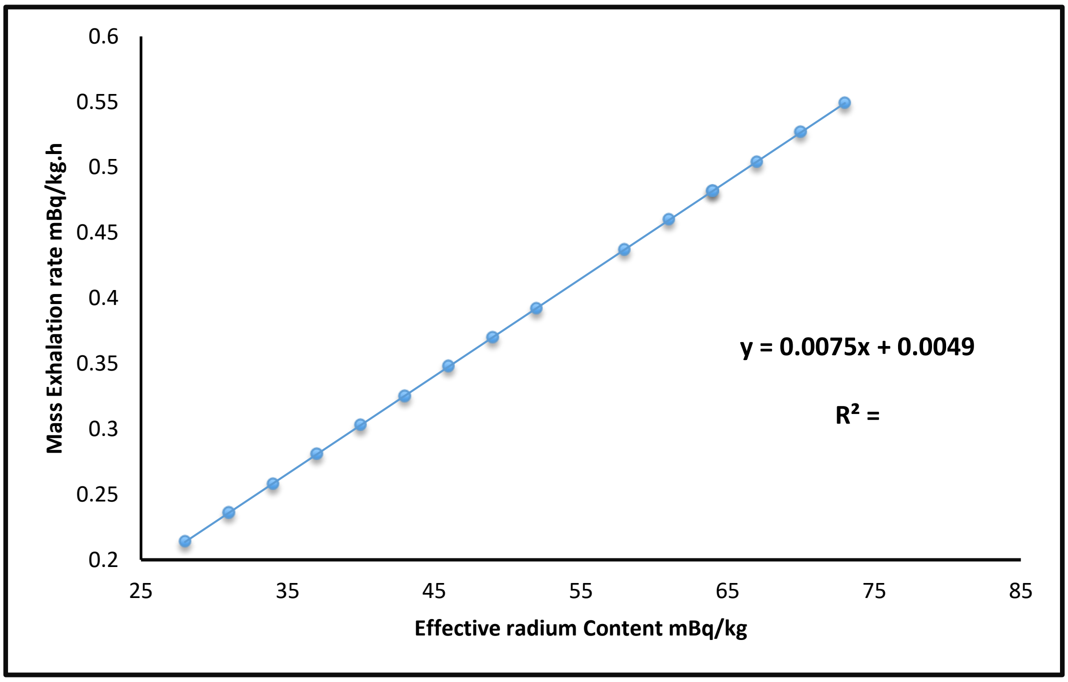

Figure 3. Liaison between radium efficient content and mass exhale ratio

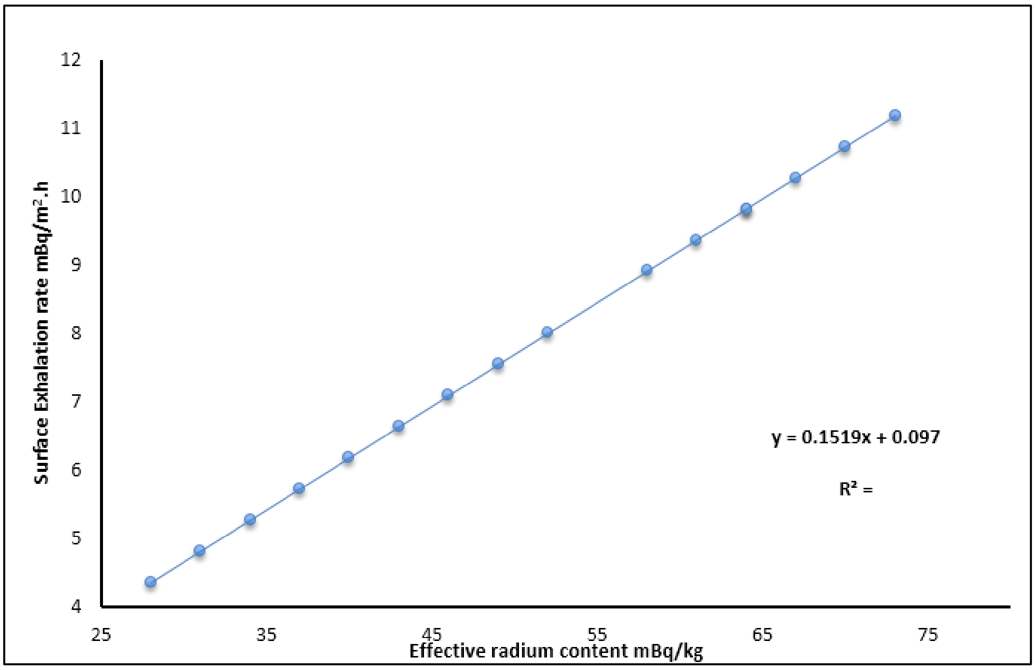

Figure 4. Liaison between efficient radium content and mass exhale ratio

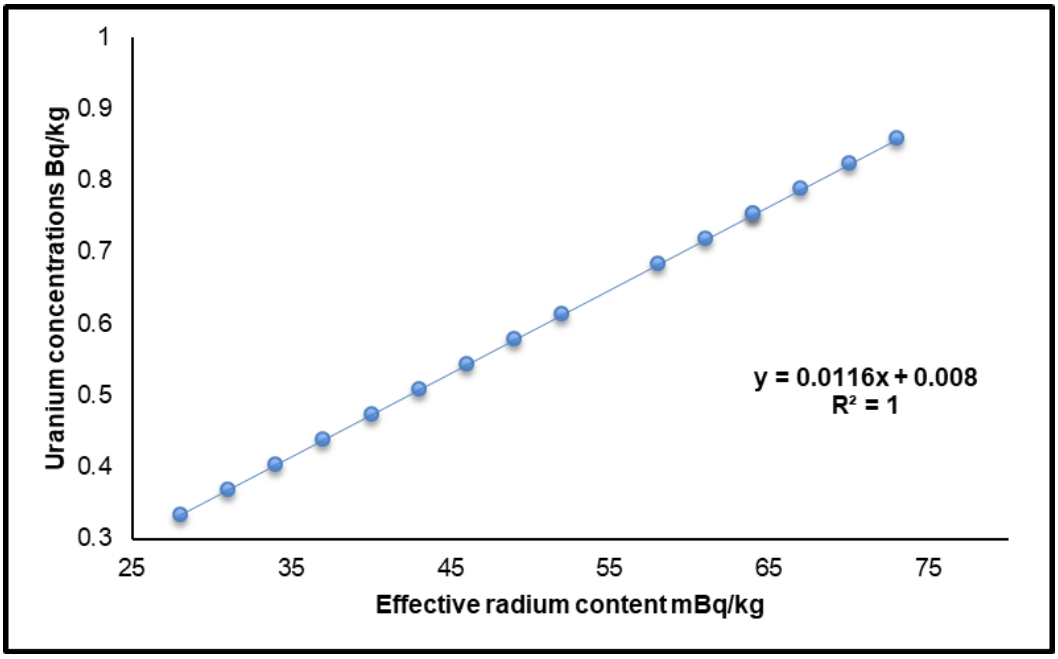

Figure 5. Liaison between efficient radium content and uranium concentrations

Conclusions

The present study examined the potent radium content, radon exhalation ratio, and uranium content in a different type of flour that is commercially available for Iraqi consumers in Karbala, Iraq. The results showed that there is a sturdy relation between the effective radium content with both uranium concentration, mass, and surface radon exhale ratio in tested samples. The differences observed in radon, radium, and uranium concentrations could be ascribed to the in variations geological nature of the different agricultural soils, and the different absorption of plant roots for specific elements present in the soil solution. In the present study, efficacious radium content, radon exhale ratio, and uranium concentration were all found to be below international permitted limits, posing no hazard to human health or life. Wherefor, it may be stated that radon absorption through the eating of food poes no major radiation hazard to the populous populace of Iraq of commercially available products presented in this study.

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