Radium and Uranium Concentrations of Powder Juice in the Iraq Markets Using CR-39 Detector

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Abstract

Powder juices are widely used by the people in the study area because its low price compared to fresh juices. These powder juices may contain some radioactive materials. The study aimed to measure radioactivity concentrations of Radium and Uranium in the most used kinds of powder juice samples, selected from Iraq markets. CR-39 detector with sealed can technique, used to measure the radioactive elements concentrations. The radionuclides observed in the present work are, the estimated radon activity concentration range is between 57.146-151.129 Bq/m^3 with a mean value of 107.62 Bq/m^3. The radon concentration mean value is within of 100 Bq/m^3 the limits of (WHO) World Health Organization reference level, below of (NRPB) UK National Radiation Protection Board, and below of 200 Bq/m^3 the European Commission Recommendation Level. The annual effective dose of radon varied between 1.441-3.813 mSv/y, are within the (UNSCEAR) range 0.2-10 mSv/y. Radium contents were found to vary between 0.188-0.498 Bq/kg and a mean value of 0.354 Bq/kg. The radium effective annual dose ranged between 1.050-2.779 μSv/y. The concentrations of uranium are in the range between 0.150-0.398 ppm with men value of 0.283 ppm. The effective annual dose of uranium varied between 1.669-4.414 μSv/y. This work helped in identifying and measuring the specified activity of radionuclide present in powdered fruit juices consuming in Iraq and showed that these kinds of powder juice are safe for consumption.

Keywords: Radium, Uranium, CR-39 detector, Powder juice, Annual effective dose.

Introduction

Recently, markets became an arena for the entry of uncontrolled goods, from various international regions, including dried powder juices, which are used by a large segment of the people because its low price compared to fresh juices. These powder juices may contain some radioactive materials, so this research had to protect from radiation by making measurements to calculate powder juice radioactivity concentrations.

Human beings face a high risk of exposure to radioactive elements, these elements have health risks that impact on their lives and may be reflected to future generations.

The damage that the body of human suffers from exposure to radioactive materials depends on some factors, on these radioactive materials, the type of radiation and on the exposed time for the body to these radiations [1]. Radioactive materials are those nuclei of elements are unstable, where the nucleus is exposed to corrosion than radiation occurs, and sooner or later the nuclei of other new elements become more stable, the process called radioactivity or radiation decay [2].

Radioactive materials when enter in the body from any pathway, absorbed and entered into the basic biochemical processes and access to the blood circulation and body fluids, they are distributed to all body tissues according to the element's properties [3]. Control the effects of internal radiation exposure to many factors, the important one is slow development and emergence of the radiation effect, and the heterogeneity of the absorption of radiation dose in the tissue along with the required time for the radioactive material decay to give a cumulative dose over time, and the degree of chemical toxicity of the radioactive element itself, and the radiation harmful effects on human body with the effects of somatic subjective the risks or effects on all types of body cells, the symptoms or effects appear in the same organism that exposed to radiation, Genetic effects of radiation, the effects that show symptoms in the offspring of organism exposed to radiation due to damage to its genitals [4], [5]. Radioactivity in living organisms is due to a number of the radioactive element's presence in the body of the organism, such as uranium, radium and radon. These radioactive elements can be fatal if consumed. Radon is the significant element can cause the cancer of the lung as in a dissolved state consumed or in gaseous form, inhaled [6]. The passive technique of CR-39 detector with sealed can used to measure radioactive Radium and Uranium in the powder juice samples.

Material and methods

Twelve samples were collected of most used dried juice powder, imported from different origins, each sample contains 90 grams of powder, these samples filled inside a plastic cylindrical container (a sealed-can diffusion chamber 7 cm in diameter, 10 cm length) facing the CR-39 track detector, the detector to the sample surface distance is 7 cm, the sample thickness of 3 cm. After 60 days the detectors etched at 6.25 N normality by NaOH and 70 C^o heat in water bath for 8 hours. The detectors washed and dried, tracks counted by a microscope at 400x a magnification.

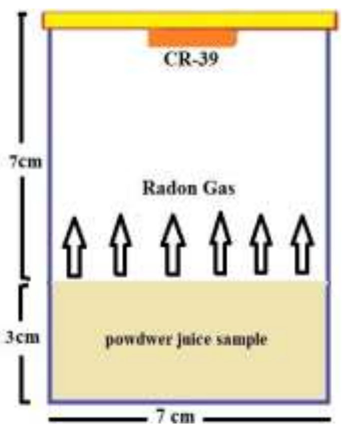

Figure 1. The sealed-can technique schematic diagram for powder juice sample.

Radon gas concentration in juice samples calculated using track densities which calculated by the equation [7], [8].

$$Track\ density\ \rho = \frac{Total\ number\ of\ tracks}{Area\ of\ the\ field\ of\ view} \qquad (1)$$

The density of tracks ρ(Track/cm^2) related to the concentration of radon activity C_{Rn}(Bq/m^3) and the time of exposure T (days) by the formula [9].

$$C_{Rn} = \rho/KT \quad (2)$$

Where K is the CR-39 calibration factor, its value (0.059 Traks.cm^{-2}.day^{-1} / Bq.m^{-3}) calculated from the equation [10], [11].

$$K = \frac{1}{4}\ r\ \left(2cos\theta_c - \frac{r}{R_i}\right) \quad (3)$$

Where θ_c is the CR-39 critical angle which it equal 35^o, r is the sealed can radius (3.5 cm), R_i the alpha particle range in air (4.09 cm for radon) calculated from the relation [12].

$$R_i = 0.318\ E_i^{\ 3/2} \quad (4)$$

Where E_i is the energy of emitted alpha particle from radon (5.49 MeV). The radon calculated concentration in the samples using the equation [13].

$$C_s = \lambda_{Rn}\ C_{Rn}\ H\ T/L \quad (5)$$

Where C_s is the Radon concentration in the powder juice samples (Bq/m^3), C_{Rn} is the air space Radon concentration in (Bq/m^3), λ_{Rn} is the decay constant for Radon (0.1814 day^{-1}), the air space height in the can is H (7cm), the exposure time is T (60 day), and the sample thickness in the can is L (3cm).

Since the effective equilibrium for Radon-Radium decay series members in about 28 days is reached, the analysis radon's alpha can used for the activity concentration determination for radium. The concentration activity of radon increases depending on time T, after the sealed can closing, by the relation [14].

$$C_{Rn} = C_{Ra}(1 - e^{-\lambda_{Rn}T}) \quad (6)$$

The content of radium in the sample is C_{Ra}, λ_{Rn} is the ^{222}Rn constant of decay. In the above expression time-integrated value measured by a plastic track detector, i.e. the alpha disintegrations total number in volume unit of the sealed can in the period of exposure time T with a calibration factor K, the observed track density is given by the relation [15].

$$\rho = KC_{Ra}T_e \quad (7)$$

Where T_e denotes, the time of effective exposure determined by:

$$T_e = \left[T - \lambda_{Rn}^{-1}\left(1 - e^{-\lambda_{Rn}T}\right)\right] \quad (8)$$

The effective content of Radium in the sample calculated by formula.

$$C_{Ra}(Bq.Kg^{-1}) = \left(\frac{\rho}{KT_e}\right)\left(\frac{HA}{M}\right) \quad (9)$$

Where soil sample mass M is in kg, A in m^2 is sealed can cross-section area, the distance between soil sample top surface and the detector is H in meter, T_e is effective exposure time in day.

The radon activity in the juice sample A_{Rn} determined through relation [16], [17].

$$A_{Rn} = C_s\ V \quad (10)$$

Where A_{Rn} the activity of radon, V the volume of juice sample $(V = \pi r^2 L)$ = 115.4 x 10^{-6} m^3, r is can radius. The radon atoms number N_{Rn} determined using the relation:

$$A_{Rn} = \lambda_{Rn}\ N_{Rn} \quad (11)$$

By the secular equilibrium (activity of uranium equal activity of radon) one can calculate the samples uranium atom number N_U from:

$$\lambda_U\ N_U = \lambda_{Rn}\ N_{Rn} \quad (12)$$

Where λ_U is the uranium decay constant (4.883 x 10^{-18} sec^{-1}), then the uranium weight in the juice samples could be calculated from:

$$W_U = N_U\ At_U\ /N_{avo.} \quad (13)$$

Where At_U uranium mass number ^{238}U, $N_{avo.}$ Avogadro number (6.02 x 10^{23} atom/mol).

Uranium concentration, then calculated by

$$C_U = W_U / W_s \qquad (14)$$

Where C_U the uranium concentration in (ppm) unit,the mass of samples W_s is used in gram (90 gm).
Activity concentration of uranium in units of (Bq.kg^{-1}) will be:

$$Ac_U = \lambda_U N_{avo.} [At_U]^{-1}\, C_U \qquad (15)$$

Where C_U must be in units of (g/kg) (1ppm=10^{-6}g/g = 10^{-3}g/kg).
The effective annual dose of radon D_{eff} (mSv/y) can be calculated from [18].

$$D_{eff} = C_{Rn} O F T_y D \qquad (16)$$

Where C_{Rn} the radon concentration (Bq/m^3), F is a factor of an equilibrium 0.4, and O is the factor for occupancy its value 0.8, T_y (8760 h.y^{-1}) in hour is a time of one year, and D is the factor of conversion (9×10^{-6}mSv.h^{-1}(Bq.m^{-3})$^{-1}$) [19].
Calculation of the annual effective dose of radium and uranium due to the ingestion of powder juice based by the developed model of the Radiological Protection International Commission [20]. From the foodstuff (f) and radionuclide (r) the effective dose D_{rf} determined by:

$$D_{rf} = C_r A_{rf} R_f \qquad (17)$$

Where the effective dose D_{rf} in (Sv.y^{-1}), C_r is the factor of effective dose conversion of the nuclide ingestion, its value 0.045 μSvBq^{-1} for uranium, 0.28 μSvBq^{-1}for radium [21], [22], A_{rf} in (Bq.kg^{-1}) is the nuclide (r) activity concentration of ingested food, the consumption rate R_f of the food (her fruit juice in kg.y^{-1}). The fruit juice consumption rate for adult is 54.6 g / day = 19.93 kg / year taken from ref. [23].

Results and Discussion

The results of measurements are listed in (Table 1), (Table 2).

Table 1. Samples, track density, Radon concentration, radon annual effective dose.

No.	Samples	ρ (Track /cm^2)	C_{Rn} (Bq/m^3)	$Rn\ D_{eff}$ (mSvy^{-1})
1	Tange / peach / Algeria	369	104.237	2.629
2	Tange / orange / Algeria	452	127.683	3.221
3	Tange / banana / Algeria	535	151.129	3.813
4	Altonsa / lemon / Turky	401.9	113.531	2.864
5	Altonsa / orange / Turky	286.8	81.016	2.044
6	Altonsa / Cocktail / Turky	312	88.135	2.223
7	Altonsa / Banana / Turky	466	131.638	3.321
8	Darina / Lebanon	202.3	57.146	1.441
9	Levanes / grapes / Turky	509	143.785	3.627
10	Levanes / apples / Turky	420	118.644	2.993
11	Levanes / orange / Turky	230	64.971	1.639
12	Levanes/apricots / Turky	388	109.604	2.765
	Min	202.3	57.146	1.441
	Max	535	151.129	3.813
	Mean	381	107.62	2.715

Table 2. Results of radium content, annual effective doses of radium and uranium, and uranium concentration.

No	C_{Ra} (Bq/Kg)	Ra D_{rf} (μSvy^{-1})	U (ppm)	U D_{rf} (μSvy^{-1})
1	0.343	1.916	0.274	3.044
2	0.420	2.348	0.336	3.729
3	0.498	2.779	0.398	4.414
4	0.374	2.087	0.299	3.315
5	0.267	1.489	0.213	2.366
6	0.290	1.620	0.232	2.574
7	0.433	2.420	0.347	3.844
8	0.188	1.050	0.150	1.669
9	0.473	2.644	0.379	4.199
10	0.391	2.181	0.312	3.465
11	0.214	1.194	0.171	1.897
12	0.361	2.015	0.288	3.201
Min	0.188	1.050	0.150	1.669
Max	0.498	2.779	0.398	4.414
Mean	0.354	1.979	0.28	3.143

The calculated Radon concentration activity values are in the range 57.146-151.129 Bq/m^3 with a mean value of 107.62 Bq/m^3. The radon concentration mean value is within the limits of 100 Bq/m^3 the reference level [24], and well below, the Board of UK National Radiation Protection Board (NRPB) and European Commission Recommendation Level of 200 Bq from ref. [25]. The effective annual dose of radon varied between 1.441-3.813 mSv/y its are within the range 0.2-10 mSv/y recommended by UNSCEAR. Radium contents were found to vary between 0.188 -0.498 Bq/kg with a mean value 0.354 Bq/kg. The radium effective annual dose ranged between 1.050-2.779 µSv/y . The concentrations of uranium are in the range between 0.150-0.398 ppm with men value of 0.283 ppm. The effective annual dose of uranium varied between 1.669-4.414 µSv/y. The minimum values found in the sample Darina-Lebanon and max value in sample Tange-banana-Algeria. (Figure. 2) represents radium content with the samples, it varies from one sample to another.

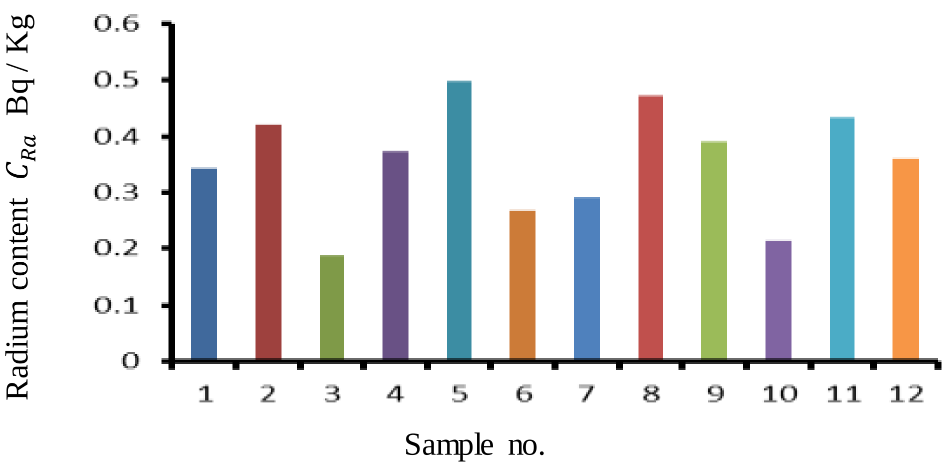

Figure 2. Radium content (Bq / kg) in samples.

In (Figure 3), a good positive correlation (1.00) obtained between the radium content and the radon concentration. It is indicated that the radon concentrations will increase as the content of radium increased.

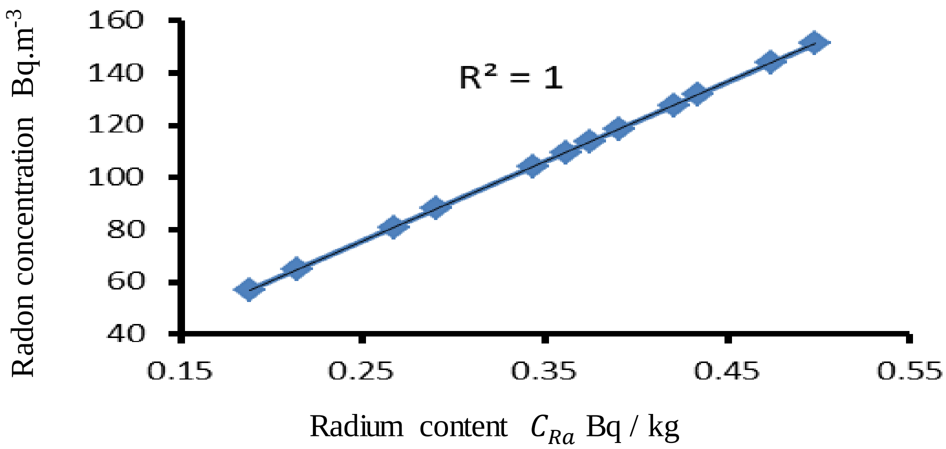

Figure 3. Relation between Radium and radon concentrations.

The results show that the concentrations activity in the samples is low strikingly and within the low background radiation limit. The most important contributors are the radionuclides naturally occurring, such as ^{226}Ra isotopes, ^{238}U being an order of lower magnitude. For uranium series, radium isotopes are the source of the dietary contamination and the internal serious radiation to man. In the series of uranium, most of the alpha particles are emitted from radium and its daughter, all the powdered fruit juice samples have high contribution to the consumer ingestion doses. Crops have uptake patterns widely different from soil to food harvest, due to transfer factor variations of their radionuclide for the pathway of soil-plant-fruit. Some crops, as apples have low radionuclides concentrations of the final fruit, while others crops such as beans, high levels exceedingly have. Processing times and longer storage can reduce the radionuclides activity contents in foodstuffs. Processing of vegetables and fruits includes washing or surface cleaning. The radionuclide removal efficiency through plant products processing widely varies and up to 99% remove the initial activity in the row of material. The surface cleaning or washing efficiency of the fruit is low and gives an initial activity reduction. Some vigorous processing more effective can be. Thus, pickling, boiling, salting, and wine production the juice[26].

Conclusions

1. The calculated values for Radon activity concentration mean value is within the reference level limits of (WHO) World Health Organization, and well below of UK National Radiation Protection Board (NRPB) and European Commission Recommendation Level.
2. The effective annual dose of radon is within the (UNSCEAR) range.
3. This work helped in identifying and measuring the specified activity of radionuclide present in powdered fruit juices consuming in Iraq, in order to determine their activity concentrations and asses the health impact on the general public who might be directly involved in the consumption fruit juices.
4. The investigation is also very useful in ascertaining the level of health risks that might be involved in the countries that consuming powdered fruit juices both internally and internationally.
5. The results show that the radionuclides presents differ in type and origin of the powder juices, due to the heterogeneity of the environments in which the

radionuclides are deposited since it could be greatly influenced by the type of soil, water, transportation and precipitation by organic metabolism or by ground water as well as other numerous factors.

6. The health impact assessment of this study revealed that the general public has not been subject to any radiological epidemiology until now when consuming these selected powder fruit juices. This due maybe to the relatively low concentrations of the radionuclides. Because of their low activity concentrations, they cannot constitute any health hazard to the general public consuming powdered fruit juices.

Conflict of Interests.
There are non-conflicts of interest

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الخلاصة

استخدمت مسحوق العصائر بصورة واسعة بسبب رخص ثمنها مقارنة بالعصائر الطازجة. هذه العصائر ربما تحتوي على بعض المواد المشعة. كان الهدف من الدراسة قياس تراكيز الراديوم واليورانيوم في بعض الانواع المختارة من الاسواق لمسحوق العصائر

الاكثر استخداما. قيست تراكيز العناصر المشعة باستخدام تقنية كاشف CR-39 الموضوع في اناء مغلق. تركيز فعالية الرادون في هذه الدراسة كانت ضمن المدى 57.146 -151.129 Bq/m^3 وبقيمة متوسطة 107.62 Bq/m^3. وهي ضمن الحدود المقبولة 100 Bq/m^3 لمنظمة الصحة العالمية (WHO), واقل من 200 Bq/m^3 التي هي مستوى لوائح الوقاية الوطنية الاوربية. الجرعة السنوية الفعالة للرادون تغيرت بين 1.441-3.813 mSv/y وهي ضمن المدى 0.2-10 mSv/y المحدد من قبل (UNSCEAR). تركيز الراديوم وجد بانه يتغير بين القيم 0.188-0.498 Bq/kg وبقيمة متوسطة 0.354 Bq/kg. والجرعة السنوية الفعالة للراديوم كانت ضمن المدى 1.050-2.779 μSv/y. تركيز اليورانيوم تغيرت بين 0.150-0.398 ppm وبقيمة متوسطة 0.283 ppm. والجرعة السنوية الفعالة لليورانيوم كانت ضمن المدى 1.669-4.414 μSv/y. هذا البحث يساهم في تعريف وقياس الفعالية المحددة للعناصر المشعة الموجودة في مسحوق العصائر المتناولة بكثرة في العراق وبينت الدراسة ان هذه الانواع من العصائر امنة للاستهلاك.

الكلمات الدالة: الراديوم، اليورانيوم، كاشف CR-39، عصير مسحوق، الجرعة السنوية الفعالة.