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Evaluation of radioactivity of cereals and legumes using a nuclear impact detector CN-85

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Abstract

The research aims to evaluate the radioactivity in elected samples of cereals and legume which are wide human consumption in Iraq using Nuclear Track Detectors (NTDs) model CN-85.
The samples were prepared scientifically according to references in this field. After 150 days of exposure, the detector were collected and chemically treated according to scientific sources (etching chemical), nuclear effects have been calculated using the optical microscope.
Radon (^{222}Rn) concentration and uranium (^{238}U) were calculated in unit Bq/m^3 and (ppm), the results indicate that the highest concentration of radon and uranium was in yellow corn where the concentration of radon was 137.17×10^2 Bq/m^3 and uranium concentration 2.63 (ppm). The lowest concentration of radon and uranium was in Oats, where the concentration of radon was 24.27×10^2 Bq/m^3, and uranium concentration 0.466 (ppm), concentrations of other cereals and legumes varied between these two values. These different in radon and uranium concentrations due to different in geological nature of the different agricultural soils, and the different absorption of plant roots for certain elements present in the soil solution. These values for the concentration of radon and uranium for cereals and legumes are within the permitted globally and as issued by the International Atomic Energy Agency (IAEA).

Key words

Radon, uranium, grains and pulses.

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تقييم النشاط الاشعاعي للحبوب والبقوليات باستخدام كاشف الاثر النوويCN-85

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الخلاصة

يهدف البحث الى تقييم النشاط الاشعاعي في العينات المنتخبة من الحبوب والبقوليات ذات الاستخدام الواسع في العراق باستخدام كواشف الاثر النووي نوع CN-85.
تم اعداد العينات وفقا للمراجع العلمية في هذا المجال، وبعد 150 يوما من التعرض، تم جمع الكواشف ومعالجتها كيميائيا (القشط الكيميائي) حسب المراجع العلمية، ثم حساب الاثار النووية باستخدام المجهر الضوئي.
تم حساب تركيز الرادون ^{222}Rn واليورانيوم ^{238}U بوحدة Bq/m^3 و (PPm)، وتشير النتائج أن أعلى تركيز للرادون واليورانيوم كان في الذرة الصفراء حيث كان تركيز الرادون Bq/m^3 137.17×10^2، وتركيز اليورانيوم (ppm) 2.63. وكان أدنى تركيز للرادون واليورانيوم في الشوفان، حيث تباين تركيز الرادون بين هاتين القيمين (وذلك بسبب اختلاف الطبيعة الجيولوجية للتربة الزاعية، واختلاف قابلية امتصاص جذور النباتات لعناصر معينة موجودة في محلول التربة)، وهذه القيم لتركيز الرادون واليورانيوم للحبوب والبقوليات تكون ضمن المسموح بها عالميا وحسب ما أصدرته الهيئة الدولية للطاقة الذرية .

Introduction

Contamination occurs in the food chain when food is exposed to radioactive material or radioactive materials were mixed with irrigation water, soil and air, for example from an reactor accident, as happened in the Chernobyl reactor explosion in Russia. Countries far away from the scene have been exposed to radiation, not just direct injury, it went beyond that from dairy, beef, grain crops, pulses and other agricultural and animal products in the Netherlands and Sweden, and that such infected products if used by the wrong hands it up to any spot in the world where it can cause damage endless without felt by the individual [1].

Food radiation contamination is a shift and change in the physical and chemical structure of food. It is possible to produce toxic compounds or become some radioactive and when eaten by humans cause many diseases, especially cancer [2].

The fall of some radioisotopes on the soil and plants leads to the entry of the human body or animal through the food chain, the radioactive material is transferred from the soil to the plant tissue by root or adsorption by the leaves through the metabolic processes carried out in the paper [3].

Radon is considered ^{222}Rn (radiant colorless gas, taste and smell) of the natural radiation that is generated as a result of spontaneous decomposition of sources of the element radium ^{226}Ra, and that the presence of radium in an area in nature depends on the presence of uranium ^{238}U, and radon the only metal that is in the case of gaseous, which is seven and a half times heavier than the air and is everywhere and at all times, and its derivatives constitute about half of the radioactive dose that affects the general public from natural sources combined [4].

Detection of radon or uranium in grains and legumes at higher than normal limits indicates a clear threat to human life. Cereals and legumes (plant proteins). The basic meal for most individuals, especially for low-income people because of the economic price cheapness compared to other food, perhaps the most important characteristic of the containment of many vitamins and important elements of the body and the most important fiber, all types of cereals and legumes share a number of benefits, including prevention of cancer, maintaining the health of bones, protecting the digestive system. Preventing high cholesterol in the body, maintaining the ideal weight, controlling blood sugar, preventing anemia, maintaining kidney health, reduce high levels of stress, regulate the hormones in the body being rich in useful compounds in addition to supplying the body with energy, where the body provides many vitamins such as: vitamin C,B1,B2 and B3, as well as it provides the body with many elements such as iron, magnesium, phosphorus, potassium, and sulfur [5].

The long-term measurement method was used to measure the concentration of radon and uranium using solid state nuclear track detectors (SSNTD's). This method is more efficient in measuring the concentration of radon and its wolves and the concentration of uranium was found [6], where detector are placed in closed spread chambers cylindrical shape and placed in front of the sample to measure the concentration of radon and close tightly to prevent leakage or exchange of air with the ocean, and after the spread of radon inside the room solves the emission of alpha particles and a balance between him and his children, and then allow the detector exposure to the sample [7].

The nuclear track detector CN-85 used in this research, which is the organic reagents and the chemical composition (C6H8N2), has a particularly good sensitivity to alpha particles and other heavy particles, the detector intensity1.52 g.cm^{-3} [8].

The theoretical part

Mechanism of occurrence of effects on the surface of the detector

The mechanism of effects on the detector surface depends on the generation of charged particles in the insulating solids have a number of effects as they pass through those substances, which can be observed using a microscope after treatment with a chemical (chemical etching) is working to show areas of damage formed. The type and shape of damage areas depend on the mass, energy and charge of the fallen particles and on the type of solid matter [9], therefore, the main effect of the particles charged on these detectors is their degradation or the cross-linking of their molecules with each other. These two effects represent major changes in the properties of the polymer (detector). The fall of radiation leads to the irritation and ionization of these molecules and thus severs the bonds between them, and damage and this damage is called the latent track [10].

The effect of ionizing radiation damaged areas show greater ability to interact with solutions alkaline like sodium hydroxide compared to correct areas because of the possession of damaged areas more energy than correct areas, so the chemical solution penetrates the irradiated areas quickly causing an impact is increasing its depth and expands in diameter with an increase etching time [11].

Propagation constant calculation

The measurement of radon concentration is based on determining the propagation constant K, which can be determined for the spread room used in this study of the following relationships [12]:

$$\rho = KCT \qquad (1)$$

where:

ρ: Intensity of track unit tr/m^2, K: propagation constant, D: density of track is represented by a unit $Tr.Cm^{-2}.h^{-1}$ According to the equation [13]:

$$D = \rho/T = K.C \qquad (2)$$

It is also possible find propagation constant depending on the geometry of the propagation chamber [14]:

$$K = \frac{1}{4} r(2Cos\theta_c - r/R_\alpha) \qquad (3)$$

where:

r: radius of the tube was used and its value 2.25 Cm, θ_c: critical angle of the detector 25^o.

R_α: extent of alpha particles in the air emitted from ^{222}Rn 4.15 cm as in the equation [15]:

$$R_\alpha = (0.005E_\alpha + 0.285)E_\alpha^{3/2} \qquad (4)$$

where: E_α represents the energy of alpha particles in a unit MeV, K=0.793 Cm length units.

Calculate the concentration of radon in the antenna space

It is possible to calculate radon concentration in antenna space of the chamber confined between the sample surface and the detector surface in the irradiation chamber in unit $Bq.m^{-3}$ relationships [16]:

$$D_{Rn^{222}} = \frac{C}{4} r(2Cos\theta_c - r/R_\alpha) \qquad (5)$$

Calculation of radon concentration in samples

Radon concentration in samples can be found from the following relationship [14]:

$$C_s = \lambda_{Rn} C_a ht / L \quad (6)$$

where:

C_s: Concentration of radon in the samples in unit $Bq.m^{-3}$.

C_a: Concentration of radon in the antenna space in unit $Bq.m^{-3}$.

λ_{Rn}: Fixed radon decomposition equals 0.1814 day.

L: The thickness of the sample is estimated at approximately 1.5 cm.

t: The irradiation time is 150 days.

Radiation efficiency A of the radon obtained from samples used in Bq units can also be found using the following relationships [6]:

$$A_{Rn} = C_s . V \quad (7)$$

$$V = \pi r^2 L \quad (8)$$

where: V sample size in units m^3, r: radiation chamber radius used 2.25 cm.

Calculation of uranium concentration

In order to calculate the concentration of uranium in the studied samples Cu (ppm) (Part per million). The number of uranium atoms can be determined N_u, Thus concentrating uranium in these samples by determining the number of radon atoms N_{Rn} based on the Radiation Balance Act [17]:

$$\lambda_{Rn} N_{Rn} = \lambda_U N_U \quad (9)$$

λ_{Rn}: Fixed radon decomposition is equal 12.1×10^{-6} S^{-1}.

λ_u: Fixed uranium decomposition is equal 4.9×10^{-18} S^{-1}.

The weight of uranium in the samples W_u (g) can be found from the equation:

$$W_u = \frac{Nu.Au}{N_{av}} \quad (10)$$

A_u : The mass number of uranium ^{238}U.

N_{av}: Avogadro number is equal to 6.02×10^{23} mol^{-1}.

To find the concentration of uranium in samples in ppm, we use the following relationship [6]:

$$C_u \text{ (ppm)} = \frac{W_u}{W_s} \quad (11)$$

W_s: The weight of the sample (g) and its amount 10 g.

Practical part

Food samples were collected from some cereals and legumes available in local markets (Oats, yellow corn, rice, lentils, wheat, chickpeas, white beans, red kidney beans, barley, green peas, mash, white beans, red beans, and Albaqlae), are grinded we obtain samples of homogeneous and fine powder to ensure consistent distribution of radioactive material in each sample , 10 grams of each sample were collected and placed in cylindrical irradiation chambers, the closures were sealed with a rubber payment of 22 days for a case secular equilibrium up to 98 % between radium and radon isotopes [18]. In order to prevent a leak of radon from outside the diffusion chambers, the rubber cover has been removed and replaced with another covering containing a piece of detector CN85 (With a thickness of 200 dimensions (1x2) cm^2), this cover was then sealed with adhesive tape and tightly while maintaining the stability of the dimension between the detector and the face of the sample, These detectors remained inside irradiation chambers for 150 days, and then taken out and exposed to chemical etching using sodium hydroxide solution NaOH and with purity up to 98%, this process will show the intensity of the effects left by the radon on the detector, the temperature associated with this process was 60 C^o and the concentration of the solution was 2.5 M, after about four hours of etching, the detectors were removed from sodium hydroxide solution, washed with distilled water and then dried and prepared under a light microscope and begin the process of detection and calculation of the number of effects arising on the face of the detector.

After calculating the number of effects shown by the reaction between the alpha particles (emitted from radon) and the detector surface facing the samples under study, the radiation background of the CN-85 detector In the same period that the reagents used were exposed to the samples under study, one of the reagents was placed in a sealed The purpose of this was to calculate the radioactive background of the CN-85 reagent, to subtract the intensity of its effects from all samples.

Results and discussion

For the purpose of determining radioactive contamination in the studied samples of legumes and grains, the concentration of radon in the antenna space and its concentration within the samples were determined by a unit Bq/m^3.

Table 1 shows the names of legumes and grains, and the intensity of the effects in unity (tr/m^2) corresponding to it, after subtracting the radiation background from both the value and the amount3×10^8(tr/m^2), and the concentration of radon in Antenna space and its concentration in samples in units Bq / m^3 per sample.

Fig. 1 shows the concentration of radon in units (Bq / m^3) of the grain and legume samples under study.

Table 1: The intensity of the effects and intensity of the radon effectiveness in the antenna space and within samples.

Sample no.	Sample name	$\rho\times10^6(tr/m^2)$	C_{air} (Bq/m^3)	$C_{sample}\times10^2(Bq/m^3)$
1	Oats	286.6	28.43	24.27
2	Yellow corn	1466.6	156.24	137.17
3	Rice	655.5	69.84	60.831
4	Lentils	816.6	86.94	75.917
5	Wheat	1180.0	117.74	103.09
6	Chickpeas	1277.7	136.14	119.327
7	White bean	1233.4	131.4	115.094
8	Red cowpea	777.77	82.34	72.7
9	Barley	500.0	50.57	43.87
10	Green bezalia	1122.2	119.54	104.67
11	Mach	1066.6	113.64	99.477
12	White cowpea	422.8	44.95	38.904
13	Red beans	1200	127.8	112.0
14	Baqlae	883.7	88.04	76.01

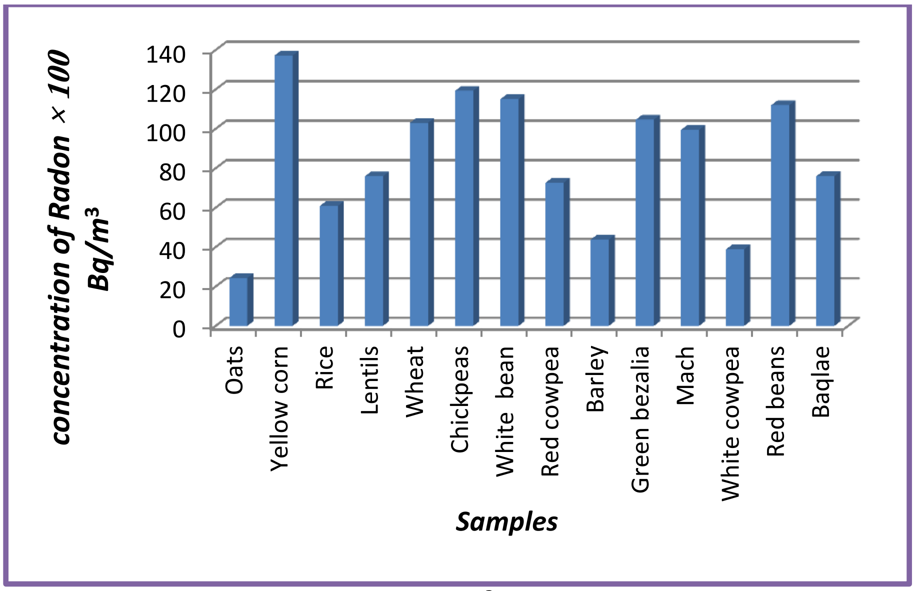

Fig.1: Concentration of radon (Bq / m^3) for legumes and grains samples.

Fig. 1 shows the concentration of radon was higher than 137.17×10^2 Bq/m^3 in the sample (Yellow corn). Then was 119.32×10^2 Bq/m^3 in the sample (Chickpeas), and 115.09×10^2 Bq/m^3 in the sample (White bean). Thus, the lowest concentration of radon was 24.27×10^2 Bq/m^3 in the sample (Oats).

Radon activity was also found in the (Bq) unit, as well as the concentration of uranium C_u(ppm) during finding the weight in W_u samples after finding the number of uranium atoms N_u of the Radiation Balance Act (between uranium and radon).

Table 2 shows the names of cereals, legumes, and radiation efficiency of the corresponding radon, number of uranium atoms N_u, weight of W_u per sample and then the concentration of the uranium in units of C_u (ppm) corresponding to each sample.

Table 2: Radiation activity of radon, number of uranium atoms, weight and concentration of samples in (ppm).

Sample name	A_{Rn}(Bq) $\times10^{-4}$	$N_u\times10^{14}$	W_u(gm) $\times10^{-6}$	C_u(ppm)
Oats	578.59	118.07	4.66	0.466
Yellow corn	3270.13	667.37	26.38	2.63
Rice	1450.21	295.96	11.69	1.1 6
Lentils	1809.69	369.96	14.59	1.45
Wheat	2455.5	501.1	19.80	1.9
Chickpeas	2751.78	569.75	23.33	2.3
White bean	2743.74	559.94	22.13	2.21
Red cowpea	1733.16	353.70	13.98	1.39
Barley	1045.86	213.44	8.43	0.84
Green bezalia	2495.33	509.25	20.13	2.01
Mach	2371.53	483.83	19.12	1.91
White cowpea	132.27	26.99	1.06	o.106
Red beans	2670.09	544.91	21.54	2.15

The highest activity value of the radon was also in the sample (Yellow corn) and value 3270.13×10^{-4} (Bq) and therefore the highest value in this sample in the number of atoms and weight of uranium and then the weight of uranium in unity (ppm) it was 2.63, followed by the sample (Chickpeas) the value of radiation activity 2751.78×10^{-4} (Bq). Thus the uranium weight (ppm) in this sample was 2.3, and the lowest activity value 578.59×10^{-4} (Bq) were in the sample (OatS) as well as the number of atoms and concentration of uranium in the unit (ppm) was the lowest value of 0.466 in this sample. The concentrations samples varied between these two values, due to the different geological nature of the soil of these samples, different absorption of plant roots for certain elements present in soil solution. These values for the concentration of uranium (ppm) for cereals and pulses are within the scope of the global permitted by the International Atomic Energy Agency (11.7) [19].

Conclusions

1-The highest concentration of radon and uranium was in the Yellow corn sample, and the lowest value was in the Oats sample.

2- These values for the concentration of radon and uranium for cereals and pulses are within the scope of the global permitted, according to the International Atomic Energy Agency.

References

[1] N. A. Dyson, Nuclear Physics with Applications in Medicine and Biology, Ellis, Harwood Limited, P 162, 1981.

[2] IAEA. Measurement of Radionuclides in food and the Environment, 1989.

[3] M. Hakim Mohammad Rushdie, Transmission of Radionuclides from Soil to Plant, Corn and Development, 12, 1 (2001).

[4] Vienna, Tech. Rep. Series No. 295, 2000.

[5] M. Sharabash and O. Ibrahim, Radiation technology in agricultural food, Arab Organization for Agricultural Development and the Arab Atomic Energy Organization, Egypt, 1996.

[6] B. A. Al-Bataina, A. M. Ismail, M. K. Kullab, K. M. Abumurad, H. Mustafa, Radiat. Meas., 28, 1-6 (1997) 591-594.

[7] R. Barillon, D. Klein, A. Chambaudet, C. Devillarad, Nucl. Trak. Radiat. Meas., 22, 1-4 (1993) 281-282.

[8] A. Najm Abdel Rahman, Solid Reagents of Nuclear Impact and Uses, Corn and Development Journal, 9, 3 (1999) 101-104.

[9] H. Al-Wondawi, Journal of Corn and Development, 9, 3 (1999) 38-41.

[10] N.P. Singh and H.S.Virk, Nucl. Tracks, l, 12 (1986) 793-796.

[11] S. A. Durrani and R. K. Bull "Solid State Nuclear Track Detection", Pergamon Press, Oxfordm (1987).

[12] M. Ahmed Obaid, Use of Nuclear Pollution Detector Technology (CR-39) for the Control of Radioactive Radiation in Depleted Uranium in Specific Areas of Salah al-Din Governorate. Proceedings of the First Scientific Conference of the Faculty of Science - Tikrit University – Iraq, 2009.

[13] Dawser Hussain Gh., Basim Khalaf R., Zainab Hazim A., Baghdad Journal of Science, 10, 2 (2013) 296-300.

[14] B. G. Cartwright and E. K., Shirk, Nucl. Inst and Meth., 153 (1978) 457-460.

[15] S.Sinch and H.S. Vrk, Indian Journal of Pure and Applied Physics, 25 (1987) 127-129.

[16] C. H. Miles and R. A. Algar Radiation Prot, Dosimetry, 74, l.3 (1997) 193-194.
[17] M. Falah Ghati, Study the Effect of Depleted Uranium on Camels in the Southern Desert of Iraq. Proceedings of the First Scientific Conference of the Faculty of Science - Faculty of Science / University of Tikrit, Iraq, 2009.
[18] A. Munib and M. Fares, Rafidain Science Journal, 8, 2 (1997) 5-8.
[19] M. Eisenbud, Environmental Radioactivity, 4th Edition Academic Press, London, 1997.