Al-Mukhtar Journal of Sciences 38 (2): 134-139, 2023
ISSIN: online 2617-2186 print 2617-2178
Journal Homepage https://omu.edu.ly/journals/index.php/mjsc/index
Doi: https://doi.org/10.54172/mjsc.v38i2.1207

Estimation of Annual Gonadal Dose Equivalent in Some Livestock Food in Libyan Markets

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ARTICLE HISTORY

Received:
5 January 2023

Accepted:
8 May 2023

Keywords:
Sodium iodide detector, Radiation concentrations, Annual gonadal dose.

Abstract: In the present study, the concentrations of ^{226}Ra, ^{232}Th, ^{238}U, and ^{40}K in 10 different samples of foodstuff are investigated using a gamma spectrometer with a Sodium iodide detector NaI(TI). The results indicated that the concentration of ^{226}Ra, ^{232}Th, ^{238}U, and ^{40}K in the samples ranged from (19.14 to 99.79) Bq/kg for radium, the activity concentration of Thorium ranged from (31.09 to 124.93) Bq/kg, the activity concentration of uranium ranged from (24.86 to 103.01) Bq/kg and the activity concentration of potassium ranged from (101.83 to 480.92) Bq/Kg. The results indicated that the annual gonadal dose equivalent (AGDE) of ^{226}Ra, ^{232}Th, and ^{40}K in the samples were higher than the permissible level (0.3mSv/y), except samples (S3, S5, S8).

تقدير الجرعات السنوية المكافئة من الغدد التناسلية في بعض أغذية المواشي في الأسواق الليبية

المستخلص : في هذه الدراسة تم حساب تراكيز ^{226}Ra, ^{232}Th, ^{238}U, ^{40}Kand في 10 عينات مختلفة من المواد الغذائية باستخدام مطياف جاما بواسطة كاشف يوديد الصوديوم (Na Tl). أشارت النتائج إلى أن تركيز Ra^{226} و Th^{232} و U^{238} و ^{40} K في العينات تراوحت بين (19.14 إلى 99.79) بيكريل / كغم للراديوم، وتراوح تركيز نشاط الثوريوم من (31.09 إلى 124.93) بيكريل / كغم، وتركيز النشاط للراديوم. تراوح اليورانيوم من (24.86 إلى 103.01) بيكريل / كغم، وتراوحت فعالية تركيز البوتاسيوم من (101.83 إلى 480.92) بيكريل / كغم. أشارت النتائج إلى أن جرعة التناسل السنوية المكافئة (AGDE) لـ Ra^{226} و Th^{232} و K^{40} كانت أعلى من المستوى المسموح به (0.3 ملي سيفرت/سنه)، باستثناء العينات (S3، S5، S8).

الكلمات المفتاحية : كاشف ايوديد الصوديوم . التركيز الإشعاعي. جرعة الغدد التناسلية

INTRODUCTION

Natural radionuclides exist in all human environments; earth materials, water, air, foods, and even our own bodies contain naturally occurring radioactive elements. The long-lived 238U, 232Th, and their decay series, as well as the 40K, are the primary natural radioactive sources of ionizing radiation (Tawalbeh et al., 2011). Radioactive elements such as uranium and thorium are also present in cement plant atmospheres (Hussein et al., 2018). The detection of radionuclides in food is an important part of the environmental monitoring program. These natural radioactive sources account for the majority of the radiation doses received by humans (Alharbi & El-Taher, 2013). As a primary constituent of cellular material, naturally occurring potassium 40K is present in almost all foods (Alharbi & El-Taher, 2013; Awudu et al., 2012;

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Canbazoğlu & Doğru, 2013; Mehra & Bala, 2014). Inhalation and ingestion are two ways radionuclides can enter the human body. Ingestion of radionuclides through food intake may account for a significant fraction of the average radiation doses to various organs of the body (Tawalbeh et al., 2011); thus, ingestion of radionuclides through food intake may account for a substantial fraction of the average radiation doses to various organs of the body, and this may also represent one of the important pathways for long-term health considerations (Al-Masri et al., 2004).

Food contains natural and man-made radionuclides that, when consumed, contribute to an effective internal dose. It is estimated that food consumption accounts for at least one-eighth of the mean annual dose due to natural sources. Average radiation doses to various organs of the body are also an important consideration for long-term health. Three long-lived naturally occurring radionuclides found in the earth's crust are 232Th, 238U (226Ra), and 40K. They typically enter the human body via the food chain (Amin & Ahmed, 2013). Natural radioactivity measurements in environmental elements have been carried out in various countries in order to establish baseline data from natural radiation levels (Ahmad et al., 2015).

The data on the radioactivity of radium, thorium, and potassium in food are related directly to population safety; thus, the purpose of this study was to provide primary radiometric data on radioactivity in grain food. The primary goal of this study is to determine the activity concentration levels of 226Ra, 232Th, 238U, and 40K in various types of foodstuff in different markets in Libya, in order to ensure that food safety is not jeopardized and that effective doses due to ingestions are within the specified safety limits. Several studies have been conducted in various countries to determine the radionuclide concentration in various food samples and the dose assessment from population consumption of that foodstuff (Awudu et al., 2012). Grains and their products are considered staple foods because they are the main component of daily meals, such as bread, rice, and pasta. The levels of radioactive materials in some grains consumed by the populace must be carefully measured to forecast any potential radiological risk.

MATERIALS AND METHODS

For radioactivity measurements, a total of ten samples of fodder, each of mass 1 Kg, were collected from different Libyan markets. These feeds included wheat, barley, corn, feed mixture, and others, which were cleaned, ground, and dried in the electric oven in the laboratory at $110C^{O}$ for one hour per sample to get rid of moisture in samples. Samples were weighed, then stored in polymer containers of 250 cm3 volume for at least 28 days to allow radioactive equilibrium to be reached. This step is necessary to ensure that radon gas is confined within the volume, and that the daughters will also remain in the sample to allow radioactive equilibrium to be reached.

The aim of this work: This work was aimed to examine the natural radionuclides in foodstuff samples used as main animal fodder. A high-efficiency NaI (TI) gamma-ray spectrometer was used to make the measurements after samples of different foodstuff were collected from local markets in Libya for the determination of the presence of natural radionuclides in some samples, which was one of the main goals in this study, as well as determining the natural concentration to estimate the radiation hazard indicators, and the equivalent annual gonadal dose equivalent (AGED) in foodstuff samples.

A Gamma-ray spectrometer with scintillation detector NaI(TI) from ORTEC was used and consists of a single crystal "3×3" inch of thallium activated sodium iodide, with an energy resolution of 7.9% and efficiency of 4.6% at 662 keV. Energy calibration and efficiency calibration of gamma spectrometer was carried out using (^{60}Co,^{137}Cs, and ^{22}Na) in the Advanced Nuclear lab-Department of Physics-faculty of Science -Omer El-Mukthar University, El-Baida, Libya. This has five gamma-ray emitters ranging from 511 keV to 2500 keV. The standard source was put over the detector with a geometric match exactly that of the geometrical sample form and with the same distance between the sample and the detector. The shield must be used to reduce the radioactive background; the shielding used in this study consists of two layers: the first of stainless steel with a width of (10 mm) and the second layer of lead (15 mm) (Sutherland & De Jong, 1990).

Table (1). Description **of the samples**

Samples No	Description
S1	Ukrainian corn [Marai El-Morouj company].
S2	Imported feed mixture.
S3	Patriotic wheat [El-Marj].
S4	Patriotic barley [El-Marj].
S5	Wheat bran [production of flour mills].
S6	Ukrainian corn [bright horizon company].
S7	Imported feed mixture [Bright Horizon company].
S8	Ukrainian wheat.
S9	Ukrainian barley [Bright Horizon company].
S10	American corn.

Calculation of activity concentration: The activity of a radiation source is the rate at which the isotope decays. Radioactivity may be thought of as the volume of radiation produced in a given amount of time. The radioactivity concentration of the different identified radionuclides was calculated by gamma-ray spectrometry with the following simple relation [Tsoulfanidies, 1983].

$$C=\frac{\text{Net area (CPS)}}{I_{\gamma}\times\xi.M} \qquad (1)$$

Where:

C= Activity concentration of the gamma spectral line in Bq/kg.

Net area (cps) = the net detected counts per second corresponding to the energy

ξ = Counting system efficiency of the energy.
M = Mass of sample in kg.
$I\gamma$= Intensity of the gamma spectral.

Calculation of Annual gonadal dose equivalent (AGDE): Gonads, bone marrow and bone surface cells are major organs to which UNSCEAR has given great importance due to their sensitivity to radiation. An increase in (AGED) has been known to affect the bone marrow, causing destruction of the red blood cells that are then replaced by white blood cells. The equivalent annual dose of gonads (AGED) from C_{Ra}, C_{Th}, and C_K activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K, respectively, was calculated, then we must calculate the annual gonadal equivalent dose for Foodstuff samples as:(Avwiri et al., 2014).

$$AGDE = (3.09C_{Ra}+4.18C_{Th}+0.134C_K)\times10^{-3} \qquad (2)$$

Where:

C_{Ra}, C_{Th}, and C_K are the activity concentration of ^{226}Ra, ^{232}Th and ^{40}K in (Bq/Kg) (El-Taher & Makhluf, 2010; Vahid, 2013).

RESULTS

Table (2). The activity concentration in (Bq/Kg) of ^{226}Ra, ^{232}Th, ^{238}U, and ^{40}K for the samples.

Sample	^{226}Ra	^{232}Th	^{238}U	^{40}K
S1	44.84	45.32	89.59	480.92
S2	19.14	59.64	61.41	446.72
S3	26.83	39	25.42	216.87
S4	78.87	62.13	75.86	278.95
S5	27.88	33.52	24.86	139.22
S6	49.49	32.84	41.36	101.83
S7	56.2	116.07	46.02	248.22
S8	45.87	31.09	45.58	115.37
S9	99.79	124.93	103.01	124.85
S10	77.35	62.87	79.86	137.8
P.L	50	15	20	420

The Activity concentrations of the studied foodstuff samples are lower than the permissible level for radium (50) Bq/Kg (UNSCEAR, 2010), except for samples No.

(S4, S7, S9, and S10) as shown in Fig. (1). The Activity concentrations are higher than the permissible level for thorium (15) Bq/Kg (UNSCEAR, 2010), for all samples as shown in Fig.(2). The Activity concentrations are higher than the permissible level for uranium (20) Bq/Kg (UNSCEAR, 2010), for all samples as shown in Fig.(3), and the activity concentrations are lower than the permissible level (420) Bq/Kg for potassium (UNSCEAR, 2010), except samples No (S1 and S2) as shown in Fig.(4).

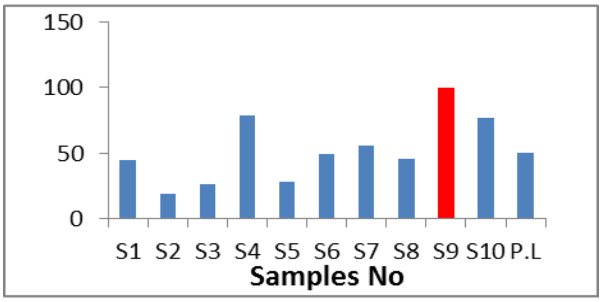


Figure: (1). The activity concentration of ^{226}Ra in samples.

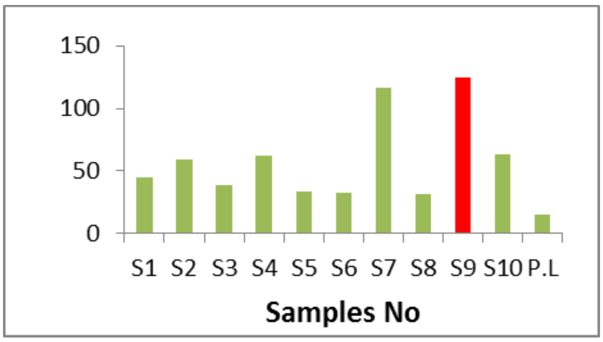
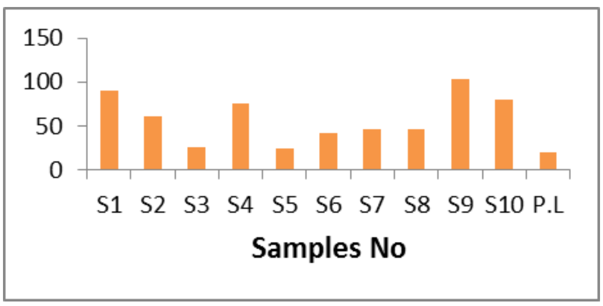


Figure: (2). The activity concentration of ^{232}Th in samples



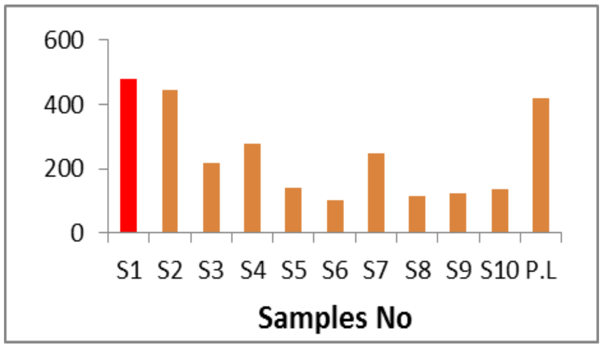


Figure: (4). The activity concentration of ^{40}K in samples

Table: (3).The values of the annual gonadal dose equivalent (AGDE) in (mSv/y)

Samples No	AGDE (mSv/y)
S1	0.39
S2	0.37
S3	0.27
S4	0.54
S5	0.24
S6	0.3
S7	0.69
S8	0.29
S9	0.85
S10	0.52
P.L	0.3

The Annual gonadal dose equivalent (AGDE) values ranged from (0.24 to 0.85) mSv/y. The annual gonadal dose equivalent values are higher than the permissible level (0.3mSv/y) (UNSCEAR, 2010), expect samples No (S3, S5, S8), as shown in Fig. (5).

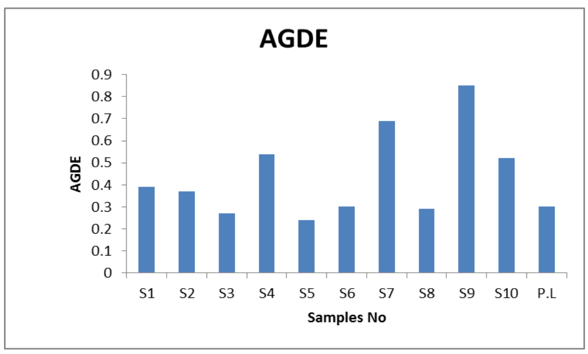


Figure: (5). The values of the annual gonadal dose equivalent (AGDE) in (mSv/y).

CONCLUSION

For ten different foodstuff samples, the activity concentration of radionuclides ^{226}Ra, ^{232}Th, ^{238}U, and ^{40}K and their radiological hazards were measured using a gamma-ray spectrometry system consisting of a NaI (Tl) detector.

In this investigation, The activity concentrations of the studied foodstuff samples are lower than the permissible level for radium except for samples No (S4, S7, S9, and S10), The Activity concentrations are higher than the permissible level for thorium for all samples, The Activity concentrations are higher than the permissible level for uranium for all samples and The Activity concentrations are lower than the permissible level for potassium, except samples (S1 and S2).

The values of annual gonadal dose equivalent are higher than the permissible level (0.3mSv/y) (UNSCEAR, 2010), expect samples No (S3, S5, S8).

Through this research, we found that the safest and most recommended food for animals is sample No.5 Wheat bran, local industry [production of flour mills].

Duality of interest: The authors declare that have no duality of interest associated with this manuscript.

Author contributions: The contribution is equal between the two authors

Funding: This manuscript did not receive funding

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