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Evaluation of the risk of cancer due to natural radioactivity in some grain-based foodstuffs

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ABSTRACT

Natural background radiation is the major source of human exposure to radioactive materials. Foodstuffs naturally contain radioactive mineral contents. The aim of this study is to determine the levels of natural radioactivity (226Ra, 232Th and 40K) in wheat flour, pasta, rice and corn in the Iraqi market. Na (Tl) detector was used to measure the concentration activity of 226Ra, 232Th and 40K in four type of foodstuff. The average activity concentrations of 226Ra, 232Th and 40K were found to be 4.498, 7.621 and 223.259 Bq.kg-1(dry weight), respectively, Iα, AUI and Hin were lower than 1 ,Absorbed Dose Rate in air (DR) 15.611 nGy h−1, Annual Gonadal Dose equivalent (AGDE) 111.252 μSv.y−1, Annual Effective Dose Equivalent (Eav.) 0.4560 mSv.y−1 and Excess lifetime cancer risk(ELCR) 1.5961× 10^{-3} also measured in wheat flour samples. While were found 4.095, 6.877 and 166.059Bq. kg-1(dry weight), respectively, Iα, AUI and Hinwere lower than 1. Absorbed Dose Rate in air (DR) 12.851nGy h−1, Annual Gonadal Dose equivalent (AGDE) 91.419 μSv.y −1, Annual Effective Dose Equivalent (Eav.) 0.1561 mSv.y−1 and Excess lifetime cancer risk (ELCR) 0.5463 × 10^{-3} in Pasta samples. Also were found 5.364, 3.039and 182.528Bq.kg-1respectively, Iα, AUI and Hinwere lower than 1 ,Absorbed Dose Rate in air (DR) 11.850 nGy h−1,Annual Gonadal Dose equivalent (AGDE) 86.582 μSv.y−1,AnnualEffectiveDoseEquivalent (Eav.) 0.327 mSv.y−1 and Excess lifetime cancer risk (ELCR) 1.143 × 10^{-3} in Rice samples. Finally were found 0.995, 0.744 and90.184 Bq.kg-1respectively, Iα, AUI and Hin were lower than 1, Absorbed Dose Rate in air (DR) 4.409 nGyh −1, Annual Gonadal Dose equivalent (AGDE) 33.875 μSv.y−1. Annual Effective Dose Equivalent (Eav.). 0.37 mSv.y−1 and Excess Lifetime Cancer Risk (ELCR) 0.129 × 10^{-3} in Corn samples. The levels of natural radioactivity in the four foodstuffs available in the local markets are not in the range of disease risks and are subject to international standards, also, a statistical significance was found among the four food items studied using statistical analysis.

Key words: ELCR, gamma spectrometry, cancer risk, wheat flour, rice corn, pasta

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INTRODUCTION

For the routine control of environmental pollution, limits are normally placed on the release of potentially harmful contaminants that may affect water, air, or soil and cause damage to the ecosystem or to human health. In the case of foodstuffs, levels of contaminants in the product are usually regulated, but primary control is nevertheless aimed at the prevention of contamination [1]. Natural radiation comes from many sources, including more than 60 naturally occurring radioactive materials found in water, soil, and air, as well as natural radon gas [2]. The sources of natural radioactivity are divided into three main types: cosmic rays, radionuclides generated as a result of cosmic rays and radionuclides of terrestrial origin [3].226 Ra with half-life 1620 (y) belong to 238U chain is one of the main pollutants in the natural radiation environment and there is widely in different ecosystems. Higher solubility of this element than uranium causes this element be washed by underground water and brought to the surface. This element is chemically similar to calcium and absorbed by plants through the soil and then through the food chain enters human's body. Almost 70% of 226Ra is accumulated in the bones and the rest spread to soft tissues of the body[4]. This radionuclide is a bone-oriented element and due to its long half-life remains in bones. However because of alpha radiation serious dangers such as bone marrow cancer can threat human health. Average annual absorption of 226Ra through the food and drink is about 19 Bq in global level that causes effective dose equivalent approximately 3.8 μSv in a year [2]. The main stages of infection entering the human food chains are [5]:

- To be uptake radionuclide by plants through leaves or roots and transferring it to fruit or in cereal and legumes to grains.
- Radionuclide transport from plants, fodder animals and animal products.
- Finally human in biological cycle, both through the polluted plants and animal products can be affected.

Therefore it is necessary to pay attention to radioactivity pollution and their mechanism absorption. Amount of radioactive pollution in various food and plants according to their absorption capacity is different. Consumed diet, consumed dosage, preparation site, and ways of preparing food, whether vegetable or animal influence on the effects that plant pollution can put on people. Considering that the main objective of the study of radioactive contamination in plant sources is the impact on humans, makes necessary to do this type of studies [3-5]. Also, the use of phosphate fertilizers in agricultural land makes multiplier radionuclide levels in soil and eventually plant contamination [6, 7]. Therefore, it is worth studying the radioactivity in commonly consumed foodstuffs and estimating the potential risk ratio in order to protect the health of the consumer, so as wheat flour, rice, corn and past was chosen because it is a traditional product prepared using wheat flour (the fiber in it makes up to 3.4%) in addition to being one of the types of pasta ,considered one of the most important common foods manufactured from grains, due to its ease of preparation, long shelf life, storage and low cost .The recipes of wheat flour from which wheat flour ,rice, corn and past are made should not exceed the percentage (moisture in it is 15%, gluten 30% and acidity 5 degrees) [8]. Wheat flour, rice, corn and past is classified into basic classes, relative to the raw materials from which it is made and various other additives, also the nutritional value of wheat flour per 100 grams (9 gm of protein,78 mg of carbohydrates, 22 mg of Calcium, 92 mg of phosphorous and 2 mg of Iron) [9]. Due to the large consumption of this food item, many studies have been conducted; the radiation risk factors were calculated for some types of pasta available in the Iraqi market [10]. Study of radioactivity and estimation of risk factors for radionuclides for some types of foods such as pasta in Jordan [11], and Measuring some important parameters and concentrations of some elements in wheat flour in China [12]. It has also been studied the activity concentrations of 226Ra, 232Th and 40K in the selected vegetables collected from different locations of Cameron Highlands, Pahang, Malaysia [13]. Specific activity in (Bq.kg-1) were estimated in unique kinds of flours that are accessible in Iraqi markets and average annual committed effective dose [14]. Measuring the level of radioactive contamination of selected samples of Sugar and Salt available in the local markets in Najaf governorate/Iraq [15]. The radiological hazard was measured in ten samples of Breakfast Cereals which collected from the Iraqi market. The corresponding radiation dose amounts and risk indices were also calculated. The mean concentrations of 226Ra, 232Th and 40K were found to be 18.195, 20.965 and 796.500 (Bq.kg-1) [16].Therefore, we deemed it necessary to study this type of food item and calculate some important transactions related directly and significantly to human health, as well as in order for a database of wheat flour, Rice, corn and pasta material to be available.

Sample preparation

Seventy six samples of the most available type's food (wheat flour, Rice, Corn and pasta) among various brand names were collected from the local markets in Iraq. To remove moisture, the samples were dried in an electric oven at 100°C for 24 hours. After drying, the samples were crushed into a fine powder to pass through a 2 mm mesh sieve. For radiation measurements, Two reference materials were packed into the same standard size beakers for efficiency calibration. Been preparing the 80 samples from wheat flour, rice, corn and pasta of local and imported origins were collected, each sample weighed 500 grams, then the samples were ground into powder and stored in special containers for NaI(TI) detector. The storage time was one month, after that, the samples were ready for measurement. Time was determined to measure samples was 3 hours also all samples were placed in the Physics Laboratory at the Faculty of Education, University of Kufa, to be ready for measurement.

Mechanism of Activity concentration measurement

Concentrations of normal radioactivity in Wheat flour, rice, corn and past samples, identified using gamma ray Na(TI) detector, which is protected by lead (15) cm thick on all sides including the upper part to reduce the radioactive background .The Wheat flour, rice, corn and past samples were placed on the top of crystal and using the gamma ray spectrometer and multichannel analyser,count spectra were obtained for each of the Wheat flour, rice, corn and past samples.

Statistical analysis

The relation among the parameters derived from natural radionuclides and the p-value is examined using statistical analysis (ANOVA), and it is 0.05 and not a lower or higher value that determines, whether the result is statistically significant or not. For statistical analysis in this paper, SPSS by Windows, standard version 20.0, was utilized as the primary statistical tool [17].

RESULT AND DISCUSSIONS

According to the results of gamma-ray spectra, the specific activity value of 226Ra, 232Th and 40K were calculated in a unit of (Bq.kg−1) was measured using Equation below [18]:

$$A_n = \frac{(G - B)}{t\varepsilon\gamma I_G m_s}$$

Where An is the specific activity (S.A) of radionuclide in the samples, G is the count rate in (CPS) for samples, B is the count rate in (CPS) for background, t is represent the time of spectra acquisition, $\varepsilon\gamma$ is detection efficiency, IG is emission probability of γ ray and, mass in (Kg) where the results of (S.A) was Fixed by Research Published [10, 14, 19].

Representative alpha index (I_α)

From the equation below, values were obtained of alpha index which was calculated for the Wheat flour, rice, corn and past samples, it was found that it was much less than one and with an average equal to 0.0055 ,which does not pose any threat or danger. The alpha index (Iα) was calculated from the equation [20]:

$$I_a = \frac{ARa}{200}$$

Activity Utilization Index (AUI)

In order to calculation of air dose rates from different groups of three radionuclides in wheat flour ,rice, corn and past by applying the appropriate conversion the indices is estimated (AUI) which given by the following expression [21]:

$$AUI = \frac{A_{Ra}}{50Bq/Kg} I_{Ra} + \frac{A_{Th}}{50Bq/Kg} I_{Th} + \frac{A_K}{50Bq/Kg} I_K$$

Where fRa, fTh and f kfK are the fractional contribution to the total dose rate in air due to gamma radiation from the actual concentration of 226Ra , 232Th and 40K , respectively (NEA–OECD) report. The average value equal to 0.0157 , this value of AUI less than two which corresponds to an annual effective dose (less than 0.3 mSv.y-1) [22].

Internal radiation hazard Index ($\mathcal{H}in$)

The internal hazard index is used to control internal exposure to 222Rn and its radioactive progeny in addition to external exposure to radon gas, dangerous for the respiratory system. Which calculate from activity concentrations of 226Ra, 232Th and 40K values of ($\mathcal{H}in$ should be less than unity in order not to pose a threat of the population [23-25].

Absorbed dose rate in air (D_R)

Natural radionuclide decay in the soil is one of the major sources of human radiation exposure. This radiation level is different depending on the con-tent of minerals and radioactive elements of each region. Gamma radiation dose due to natural radioactive contents of the soil is important to population of the area that they live in. Absorbed dose rate in air for radionuclide were calculated based on provided guidance as follows [26].

D (nGy.h-1) = (0.462ARa + 0.604ATh + 0.0417AK)

In which ARa, AK, and ATh respectively are the average activity concentrations of 226Ra, 40K, 232Th in terms of Bq.kg.

Annual Gonadal Equivalent Dose (AGED)

Was also calculated due to that the reproductive gland is important due to its high sensitivity to radiation [27]. The latter index is classified as highly important in the UNSCEAR 2000 publication[28] .Therefore, it is essential to calculate the Annual Gonadal Equivalent Dose (AGED) depending on the specific activities of 226Ra, 232Th, and 40K [5]:

$$AGED = 3.09A_{Ra} + 4.18A_{Th} + 0.314A_k$$

The Average Annual Committed Effective Dose ($E_{av.}$) to an individual, due to consumption of the four food groups studied by the ingestion of naturally occurring radioactive materials (NORMs) was estimated using the equation [29].

$$Eav. = Cr\ DCF_i A_i$$

where, $Eav.$ is the average annual committed effective dose, Cr is the consumption rate of radionuclides, the annual effective ingestion dose due to the consumption of wheat grains was calculated based on annual intake of 108 kg.y-1(dry weight) of wheat grains ,42 kg.y-1, 98 kg.y-1 and 38 kg.y-1 by adults in Iraq, and $DCFi$ is the dose conversion factor for each radionuclide (2.8×10^{-7}, 2.3×10^{-7}, 6.2×10^{-9}) Sv.Bq-1 for 226Ra, 232Th, 40K, respectively),and Ai is the activity concentration of each radionuclide .Using the same equation, the annual threshold consumption rate for a medicinal plant is obtained [30]:

$$Cr = \frac{3Eav.}{\Sigma_i^3 (DCF_i \times A_i)}$$

where, E_{av}.= 0.3mSv.y-1 for 5 E_{av}. is the threshold average annual committed effective dose due to ingestion of NORMs in the medicinal plants but equal 0.324mSv.y-1, A_i is the activity concentration of radionuclide i, and DCFi is the dose conversion factor for radionuclide i (UNSCEAR, 2000).

Excess Lifetime Cancer Risk (ELCR)

Excess lifetime cancer risk (ELCR) is calculated using the following equation and presented in table (3) [31, 32].

$$ELCR = Eav. * LS * RF$$

Where $Eav.$ (annual ingestion dose) where was less than the dose

Tab. 1. Origins of Wheat Flour samples with activity concentration and radiation hazard indices

ID	Origin	Specific Activity (Bq.kg^{-1})			Radiation hazard indices < 1		
		226Ra	232Th	40K	Iα	AUI	Hin
WG1	UK	1.32	1.43	201.73	0.007	0.046	0.055
WG2	Southern Africa	0.91	0.72	99.26	0.005	0.025	0.028
WG3	Italy	0.04	0.56	73.97	< LD	0.013	0.018
WG4	Oman	2.39	0.91	299.1	0.012	0.058	0.079
WG5	France	0.63	0.09	161.2	0.003	0.02	0.037
WG6	Germany	0.63	5.71	170.74	0.003	0.089	0.061
WG7	UK	1.06	12.8	99.93	0.005	0.173	0.076
WG8	UK	0.48	0.01	87.74	0.002	0.012	0.021
WG9	UK	1.02	0.56	203.24	0.005	0.033	0.05
WG10	France	1.01	0.9	81.77	0.005	0.027	0.026
WG11	Poland	0.5	1.04	119.01	0.003	0.027	0.032
WG12	Lebanon	1.87	2.24	123.17	0.009	0.054	0.044
WG13	UK	0.05	0.77	134.62	< LD	0.021	0.031
WG14	Germany	0.59	1.13	71.88	0.003	0.025	0.023
WG15	UK	1.45	0.49	161.66	0.007	0.033	0.043
WG16	Turkey	10.401	10.603	300.504	0.052	0.249	0.16
WG17	Iran	11.735	26.938	400.85	0.059	0.467	0.251
WG18	Iran	12.751	13.578	250.892	0.064	0.302	0.174
WG19	Iran	11.546	12.373	311.961	0.058	0.282	0.175
WG20	Iraq	9.864	12.976	268.155	0.049	0.27	0.159
WG21	Iran	4.802	11.648	299.725	0.024	0.21	0.133
WG22	Iraq	8.533	12.561	287.818	0.043	0.254	0.155
WG23	Iraq	8.401	11.507	298.706	0.042	0.241	0.152
WG24	Iran	9.188	12.439	297.456	0.046	0.26	0.16
WG25	Turkey	3.026	17.232	499.82	0.015	0.277	0.187
Max.		12.751	26.938	499.82	0.064	0.467	0.251
Min.		0.04	0.01	71.88	< LD	0.012	0.018
average		4.498	7.621	223.259	0.022	0.151	0.096

limit of (250–400)*10^{-3} [33], the annual equivalent effective dose which was calculated using its own formula [13] , DL and RF are Life span (70 years) and risk factor (0.05) per Sievert ICRP .The ELCR with an average value (0.0057) which was less than (2.5*10^{-3}) recommended by ICRP and WHO [33], from the results we obtained is that the risk of developing cancer is below the internationally recommended limits, so wheat flour, rice, corn and past samples are healthy for consumers.

Table 1, included 25 samples of different origins from wheat flour, by examining the results of the table, it was found that sample WG3 of Italian origin is the lowest in terms of the specific effectiveness of 226Ra and 40k nuclides, as well as in relation to the risk factors (Iα and Hin), but the concentration of 232Th and index AUI was the lowest in sample WG8 of British origin. However, the highest percentages were in the sample WG17 of Iranian origin for the concentration of 232Th and the two factors (AUI and Hin). The sample of WG18 of Iranian origin is also the highest in terms of 226Ra concentration and the alpha coefficient Iα, while the concentration of 40k was highest in the sample WG25 of Turkish origin. It can be said that the average concentrations of the studied samples and for all origins are less than the permissible limits globally.

Table 2, included 24 samples of different origins of pasta. By examining the results of the table, it was found that sample PM3 of Turkish origin is the highest in terms of the specific effectiveness of Radium-226 and Thorium-232 nuclides, as well as for the three hazard indices (Hin, AUI and Iα), but the concentration of potassium- 40 was the highest in sample PM1 of Turkish origin. But the lowest concentration was in sample PM18 of Italian origin for Radium-226 concentration, and sample PM24 of Indonesian origin for potassium-40. But the concentration of Thorium-232 and the three hazard indices were the lowest in the sample PM14(Iraq), and it can be said that the average concentrations of the studied samples and for all origins are less than the internationally permissible limits (UNSCEAR 2008).

Table 3, included 18 samples of different origins of rice. By examining the results of the table, it was found that sample RC4 of Turkish origin is the highest in terms of the specific effectiveness of Radium-226 nuclide and the lowest concentration in the sample RC16 of Italian origin, but the concentration of Thorium-232 was highest in sample RC8 of Iraqi origin and lowest in sample 18 of Spanish origin . It was also noted from the table that the potassium concentration level and the three risk coefficients were the highest in the sample 8 of Iraqi origin and the lowest in the sample of Spanish origin RC18 except for the alpha coefficient Iα, which was the lowest in the Italian sample 16 and all treatments were safe from the health side.

Table 4, included 13 samples of different origins of maize. By examining the results of the table, it was found that sample CN8 of Lebanese origin is the highest in terms of specific activity of Radium-226 nuclide and the lowest concentration in sample CN9 of Iraqi origin, but the concentration of Thorium-232 was the highest in sample CN7 of Iraqi origin and lowest in sample CN3 of German origin. It was also noted from the table above that the level of potassium-40 concentration was the lowest in sample CN4 of Britain and the highest in sample CN7of Iraqi origin. As for the three risk indices, the highest was in sample CN8 of Lebanese origin (Iα and AUI), but (Hin) was the highest in sample CN7 of Iraqi origin. It was also noted that alpha was the lowest concentration in sample CN9.

AUI index hazard has a lower concentration in the sample CN3 Germany and the Hin have a lower concentration in the sample CN4 Britain(UK).

Tab. 2. Origins of Pasta samples with activity concentration and radiation hazard indices

ID	Origin	Specific Activity (Bq.kg^{-1})			Radiation hazard indices < 1		
		226Ra	232Th	40K	Iα	AUI	Hin
PM1	Turkey	3.702	7.207	305.822	0.019	0.146	0.111
PM2	Turkey	9.542	13.418	79.357	0.048	0.257	0.12
PM3	Turkey	0.91	0.067	299.495	0.005	0.034	0.067
PM4	Turkey	21.8	19.034	120.219	0.109	0.441	0.216
PM5	Turkey	2.309	15.027	198.881	0.012	0.219	0.112
PM6	Turkey	4.37	0.768	86.724	0.022	0.057	0.045
PM7	Iran	6.012	15.542	102.873	0.03	0.252	0.114
PM8	Iran	0.258	2.538	189.186	0.001	0.049	0.051
PM9	Iran	0.681	13.601	91.397	0.003	0.178	0.075
PM10	Iran	0.709	0.116	139.227	0.004	0.019	0.033
PM11	Iran	2.765	3.278	129.074	0.014	0.076	0.054
PM12	Iran	3.543	10.652	304.242	0.018	0.186	0.124
PM13	Iraq	10.036	11.907	117.991	0.05	0.246	0.125
PM14	Iraq	0.207	0.017	64.484	0.001	0.007	0.015
PM15	Italy	3.187	13.8	99.086	0.016	0.204	0.091
PM16	Italy	6.451	17.03	101.583	0.032	0.274	0.122
PM17	Italy	0.536	0.099	287.162	0.003	0.03	0.063
PM18	Italy	0.155	0.112	282.535	0.001	0.026	0.06
PM19	Italy	1.65	0.502	189.108	0.008	0.037	0.05
PM20	Italy	0.9	0.045	240.321	0.005	0.029	0.055
PM21	Italy	0.211	2.058	184.364	0.001	0.042	0.047
PM22	Kuwait	0.526	1.203	78.39	0.003	0.026	0.024
PM23	UAE	1.18	0.08	209.87	0.006	0.029	0.05
PM24	Indonesia	2.864	11.658	55.159	0.014	0.172	0.072
Max.		21.8	19.034	305.822	0.109	0.441	0.216
Min.		0.155	0.017	55.159	0.001	0.007	0.015
average		4.095	6.877	166.059	0.021	0.134	0.082

Tab. 3. Origins of rice samples with activity concentration and radiation hazard indices

ID	Origin	Specific Activity (Bq.kg^{-1})			Radiation hazard indices < 1		
		226Ra	232Th	40K	Iα	AUI	Hin
RC1	IRAQ	6.44	5.17	305.48	0.032	0.147	0.118
RC2	IRAN	3.12	4.6	224.54	0.016	0.103	0.081
RC3	IRAQ	8.64	2.9	176.61	0.043	0.129	0.095
RC4	Turkey	9.89	2.21	105.16	0.049	0.127	0.084
RC5	IRAQ	6.78	2.48	208.19	0.034	0.11	0.09
RC6	IRAQ	9.21	6.04	146.29	0.046	0.17	0.104
RC7	IRAQ	3.18	3.09	107.49	0.016	0.076	0.052
RC8	IRAQ	9.73	6.34	411.83	0.049	0.2	0.163
RC9	Turkey	0.98	0.36	214.16	0.005	0.031	0.051
RC10	Turkey	0.54	0.93	88.89	0.003	0.024	0.025
RC11	Turkey	8.61	4.91	215.48	0.043	0.157	0.11
RC12	Turkey	4.12	5.1	113.54	0.021	0.109	0.066
RC13	Turkey	0.84	0.42	53.62	0.004	0.017	0.017
RC14	Poland	7.46	3.1	152.61	0.037	0.119	0.084
RC15	France	8.77	1.91	181.16	0.044	0.119	0.092
RC16	Italy	0.43	0.54	278.7	0.002	0.033	0.062
RC17	Lebanon	7.68	4.11	205.19	0.038	0.137	0.1
RC18	Spain	0.54	0.11	24.89	0.003	0.008	0.009
Max.		9.89	6.34	411.83	0.049	0.2	0.163
Min.		0.43	0.11	24.89	0.002	0.008	0.009
average		5.364	3.039	182.528	0.027	0.101	0.079

Tab. 4. Origins of corn samples with activity concentration and radiation hazard indices

ID	Origin	Specific Activity (Bq.kg^{-1})			Radiation hazard) indices < 1)		
		226Ra	232Th	40K	Iα	AUI	Hin
CN1	Germany	0.77	0.45	42.93	0.004	0.016	0.015
CN2	UK	0.79	0.67	79.12	0.004	0.022	0.023
CN3	Germany	0.12	0.02	41.69	0.001	0.005	0.009
CN4	UK	0.32	0.12	21.86	0.002	0.006	0.007
CN5	Turkey	0.19	0.36	42.41	0.001	0.01	0.011
CN6	Lebanon	0.82	1.04	99.54	0.004	0.028	0.029
CN7	Iraq	0.81	1.71	175.66	0.004	0.043	0.048
CN8	Lebanon	4.21	0.86	98.5	0.021	0.057	0.047
CN9	Iraq	0.12	0.28	93.46	0.001	0.012	0.021
CN10	Germany	1.3	0.61	132.21	0.007	0.03	0.037
CN11	Iran	0.15	1.07	101.48	0.001	0.023	0.026
CN12	IRAQ	0.51	1.01	89.65	0.003	0.024	0.025
CN13	Lebanon	0.49	1.24	136.73	0.002	0.031	0.036
Max.		4.21	1.71	175.66	0.021	0.057	0.048
Min.		0.12	0.02	21.86	0.001	0.005	0.007
average		0.995	0.744	90.184	0.005	0.025	0.026

Tab. 5. Absorbed dose rate in air (dr), annual gonadal dose equivalent (agde), annual effective dose equivalent (eav.) and excess lifetime cancer risk (elcr) in wheat flour and pasta samples.

Sq.	Wheat flour				Pasta			
	DR (nGy h^{-1})	AGED μSv.y^{-1}	$Eav.$ mSv.y^{-1}	ELCR× 10-3	DR (nGy h^{-1})	AGED μSv.y^{-1}	$Eav.$ mSv.y^{-1}	ELCR× 10^{-3}
1	9.885	73.399	0.2105	0.7368	19.202	137.593	0.1928	0.6748
2	4.833	36.989	0.1119	0.3915	16.07	110.49	0.2625	0.9187
3	3.269	25.691	0.0647	0.2263	13.011	97.133	0.0893	0.3127
4	14.184	105.106	0.2952	1.033	26.779	184.673	0.4715	1.6504
5	6.96	52.94	0.1292	0.4523	19.186	132.396	0.2241	0.7844
6	11.091	79.427	0.2752	0.9633	5.804	43.945	0.0814	0.2849
7	12.923	88.157	0.4169	1.4592	16.979	115.845	0.2476	0.8667
8	3.684	29.075	0.0735	0.2573	9.625	70.81	0.0768	0.2689
9	9.246	69.31	0.1808	0.633	12.925	87.655	0.1632	0.5712
10	4.243	32.559	0.1077	0.3768	6.066	46.393	0.0457	0.16
11	5.719	43.261	0.1206	0.4222	8.601	62.775	0.0978	0.3423
12	7.278	53.817	0.1947	0.6813	21.347	151.005	0.2238	0.7833
13	6.02	45.644	0.1108	0.3877	16.941	117.832	0.2638	0.9232
14	3.791	29.117	0.094	0.3291	2.572	20.959	0.0194	0.0679
15	7.595	57.29	0.1643	0.5749	14.457	98.645	0.1966	0.6881
16	24.082	170.818	0.7791	2.7269	18.097	123.016	0.2668	0.9339
17	39.78	274.729	1.2924	4.5235	12.342	92.239	0.082	0.2871
18	24.922	174.937	0.8909	3.118	11.989	89.662	0.0765	0.2677
19	26.235	185.352	0.8654	3.0288	8.869	66.577	0.0735	0.2572

CONCLUSION

A sensitive experimental approach for studying natural radioactivity and figuring out radionuclide concentrations and dose rates in various samples of wheat flour, rice, pasta, and corn is the use of high-resolution-ray spectroscopy. Low values for radioactive concentrations of 226Ra, 232Th, and 40K were found in the samples examined for this study, which contributed to the low absorbed dose rates in the air. Also, the studied radiometric parameters AGDE, Eav and ELCR for each type of food were found to be within the permissible limits of health organizations. The current investigation of the radioactivity of four classes of foodstuffs is the first of its kind at the national level. It has been discovered that ingestion of this kind of food is safe in the groups examined. The relationship among the studied groups was statistically significant, that is, the p-value is less than 0.05, this may be due to the difference in the annual intake value among foodstuffs. The research's conclusions will aid in establishing a baseline of radiation exposure from food consumption for the (adults) general public.

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ETHICAL APPROVAL

The study protocol was approved by local ethics committee.

DISCLAIMER

None

CONFLICT OF INTEREST

There are no conflicts of interest to declare.

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