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Studies of ^{226}Ra, ^{28}Th and ^{40}K Concentrations in Cooking Oil and Estimation the Radiological Hazards to Human Health

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Abstract

The specific activity of Uranium (^{238}U),Thorium (^{232}Th) and Potassium (^{40}K) were measured in different brands of cooking oil that are available in Saudi Arabia markets. The gamma spectrometry method with *high-purity germanium (HPGe) detector* was used. The results indicate that the activity concentrations measured for 226Ra varied from 0.23 to 6.05 Bq l^{-1} , 232Th varied from 0.68 to 2.89Bq l^{-1} and 40K from 1.32 to 21.81Bq l^{-1}.The corresponding average activity concentrations of 226Ra, 228Th and 40K were found to be 2.41, 0.85 and 8.87Bq l^{-1}, respectively. The total annual effective dose was estimated to be 9.51µSvy^{-1} which is less than the world total dose value 290 µSvy^{-1} for all food reported by UNSCEAR 2000. The results show that all the examined samples do not create any significant source of radiation hazard and safe for the public health.

Keywords: Natural radioactivity; absorbed dose; annual effective dose.

1. Introduction

The naturally occurring radionuclides ^{238}U and ^{232}Th series and 40K are the major source of natural radiation exposure to human beings. The total exposure per person was 0.29mSv/y by consuming foodstuff and 0.01mSv/y by inhalation the terrestrial radioisotope [1]. The assessment of radionuclide levels in a variety of food is crucial to determine intake of these radionuclides by people. Accordingly, several studies investigated the natural radionuclides in consumed foodstuff in many countries [2- 10].

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However, in Saudi Arabia, a few surveys of radioactivity in food have been conducted [11-14] . For that reason, it is essential to carry out regular monitoring of foodstuffs in particular cooking oil. In Saudi Arabia, many brands of oil is being used in cooking food (in restaurants, houses and public buildings), these brands are local and imported from different countries around the world. Thus, the knowledge about the safety of the cooking oil is very important for the health of consumers. The aim of this work is to measure the concentration of natural radionuclides 40K, 238U, 232Th in different types of cooking oil in Saudi Arabia. This study presents essential guidelines of protection against high levels of internal exposure that might be occurred by food consumption and considered a part of the radiological baseline information for Saudi Arabia and the world. Additionally, this type of work allows establishing baseline values for comparison with future measurements.

2. Materials and methods

Twenty two samples of the most available local and imported types of oil were collected from different markets in Jeddah city, Saudi Arabia to determine their natural activity. The oil samples were listed in Table (1) . About 0.5 Liter of each sample was filled in a Marinelli beaker, sealed and then stored for four weeks before taking the measurement to ensure secular equilibrium between 222Rn and its radioactive[15]. The gamma-ray spectra of the samples were measured using a hyper-pure germanium detector (HPGe) with 25% efficiency and 2keV resolution at 1332 keV gamma line of ^{60}Co were employed for all the measurements. Genie 2000 computer software performed the spectrum analysis. Each sample after equilibrium was placed on top of the HPGe detector and counted for 36000s. The background radiation was measured every week under the same conditions of the sample. The activities of ^{226}Ra and ^{232}Th were determined through the full absorption peaks of the ^{214}Bi (609.0, 1120.3 and 1764.5 keV), ^{214}Pb (351.0 keV),^{228}Ac (911.2 keV), ^{212}Pb (238.6 keV) and ^{208}Tl (583.2 keV). 40K activities were estimated from gamma-peaks 1460.8 keV.

The activity concentration was calculated by using the following equation (15,16] :-

$$A\ (Bq\ l^{-1}) = C_a / \varepsilon\ p_\gamma\ v \qquad (1)$$

Where A is the activity of the radionuclide in Bq l^{-1}, C_a the counts per second, ε the detection absolute efficiency at a specific γ–ray energy and p_γ the emission probability of Gamma–decay and V is the volume of the oil sample in a liter.

3. Exposure and dose rate

The estimated annual effective dose equivalent is calculated from the absorbed dose rate by applying dose conversion factor of (0.7Sv/Gy) and the occupancy factor for indoor was 0.2 . D_{eff} (mSv/y) is determined using the following equation [1]:-

$$D_{eff}\ (mSv/y) = \text{Absorbed effective dose (nGy /h)} \times 8760\ (h/y) \times 0.7 (Sv/Gy)) \times 0.2 \times 10^{-6} \qquad (2)$$

Where :-

Absorbed effective dose (nGy /h) = $0.427C_{Ra} + 0.623C_{Th} + 0.043C_K$.(3)

Where 0.427, 0.623 and 0.043 ($nGyh^{-1}Bql^{-1}$) are the conversion factors for Ra , Th and K, respectively , and C_{Ra}, C_{Th} and C_K are the activity concentrations (Bq/ l) of ^{226}Ra, ^{232}Th and ^{40}K , respectively, [1] .

Excess lifetime cancer risk (Rc)

To determine cancer risk for an adult individual by using the following relationship (5,11]

$$Rc = Deff \times RF (Sv^{-1}) \times DL \quad (4)$$

Where: - RF is a risk factor (Sv^{-1}), fatal cancer risk per Sever. For the public its value of 0.05 [17] . Deff is the total effective dose , DL is duration of life (50 year.

4. Results and discussions

Table 1 presents the specific activity for the radionuclides in the twenty two oil samples. In this study, ^{232}Th ^{226}Ra, ^{40}K were detected , whereas ^{137}Cs was below the limit of detection. ^{238}U was detected in all samples with the highest value (6.05±0.08Bq/l) in S7 ,while the lowest value (0.23±0.02 Bq/l is found in sample S12, with an average value 2.41Bq/l . For 232Th , it was detected only in 11 samples, the highest value was found in S14which was equal to (2.89±0.178Bq/l),while the lowest value 0.68±0.04 $Bql^{-1}$was found in sample S2, with an average value of(0.85Bq/l). ^{40}K was not detected in 6 samples and for the other samples 40K was detected with reasonable activity concentration levels , where , the highest value of 40K activity was (21.81±0.51Bq/l) a lowest value of (1.32±0.06Bql^{1}) , and all brands average of 8.87 Bql^{1}. The average values of 226Ra, 232Th and 40K activity concentrations for all oil samples were lower than the WHO guideline limit of 10Bq l^{-1} , 1Bq l^{-1}. 100Bq l^{-1} for 226Ra, 232Th and 40K respectively, and are much lower than the activity values reported by UNSEAR2000. No data were found in the litertures for natural activity in cookin oil to be compared with the the results of the present work.

Figurr 1(a,b and c) shows a comparison of the activity concentrations of the radionuclides in oil samples in the present work. The annual effective dose of radionuclides existed in cooking oil is presented in Table 1. The highest value of indoor annual effective dose rate (Deff) in S_1 was 18.26μSv/y, while the lowest value of indoor annual effective dose rate was found in S_{13}, which was equal to (2.47μSv/y, with an average value of (9.51 μSv/y). The world dose value for all foodstuffs is 290μSv y^{-1} as cited by [1] . The current results of the indoor annual effective doses for all the samples were less than the value of (20mSv/y) for the indoor annual effective dose equivalent given by worldwide Average [1]. As a result, no harmful radiological health effects are expected from the consumption of oil in cooking food from the studied samples. The annual effective dose in oil samples is illustrated in Figure2. Table 1, shows the calculated cancer risk values due to spices range from $0.0.06x10^{-3}$ to 0.46 $x10^{-4}$ with an average of $0.24x10^{-4}$. This average value compares with other types of health risks which gives a risk factor of 0.48 × 10^{-4} due to foodstuff [5]. The present estimated values cancer is lower than the world average (2.9x10^{-4}) reported by [1]. This means that consumption of cooking oil does not generate any sort of radiological health risk.

Table 1: Radioactivity concentrations , annual effective dose and cancer risk in different cooking oil samples collected from a local market in Jeddah city, Saudi Arabia

	Sample code no.	Activity concentration (Bq L^{-1})			Annual effective dose (µSv/y)	Cancer risk ×10^{-4}
		226Ra	232Th	40K		
Local samples	S1	4.72±0.03	1.61±0.06	16.36±0.58	18.26	0.46
	S2	1.75±0.03	0.680.02	16.65±0.12	9.27	0.23
	S3	1.62±0.02	ND	ND	3.39	0.08
	S4	0.96±0.04	ND	2.86±0.07	2.61	0.07
	S5	2.56±0.03	1.43±0.5	8.57±0.22	11.54	0.29
	S6	1.24±0.06	ND	11.16±0.49	4.95	0.12
	S7	6.05±0.08	1.31±0.03	10.91±0.28	18.98	0.47
	S8	0.27±0.07	1.75±0.04	1.32±0.06	6.19	0.15
	S9	5.96±0.03	ND	17.65±0.45	16.21	0.41
	S10	4.12±0.04	ND	10.38±0.25	10.82	0.27
	S11	0.31±0.05	ND	20.51±0.59	4.98	0.12
	S12	0.23±0.02	ND	21.81±0.51	5.08	0.13
	S13	1.18±0.06	ND	ND	2.47	0.06
	S14	5.42±0.09	2.89±0.17	ND	20.19	0.50
	S15	1.41±0.06	0.75±0.04	13.49±0.21	8.09	0.20
	S16	3.25±0.08	1.92±0.3	2.08±0.11	13.11	0.33
	S17	2.41±0.08	ND	8.05±0.31	6.75	0.17
	S18	2.89±0.07	1.56±0.04	ND	10.82	0.27
	S19	0.71±0.03	1.40±0.03	12.98±0.19	8.50	0.21
Imported Samples	S20	2.99±0.07	1.65±0.03	20.25±0.32	15.58	0.39
	S21	1.73±0.06	0.94±0.02	ND	6.49	0.16
	S22	1.230.05	0.79±0.02	ND	4.99	0.12
Range		0.23 - 6.05	0.68-2.89	1.32-21.81	2.47-18.26	0.06-0.46
Average		2.41	0.85	8.87	9.51	0.24

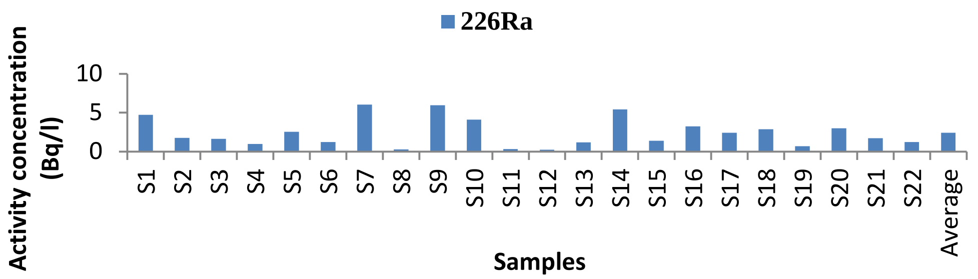
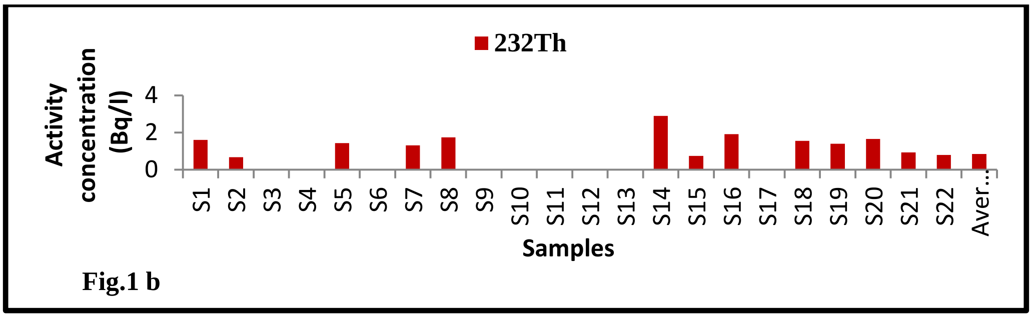


Fig.1 a



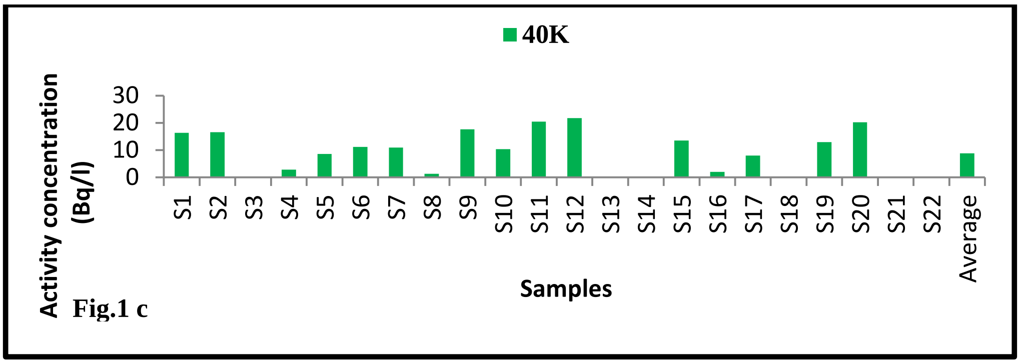


Figure 1: (a,b and c). Activity concentrations of 226Ra , 232Th and 40K in oil samples , Saudi Arabia

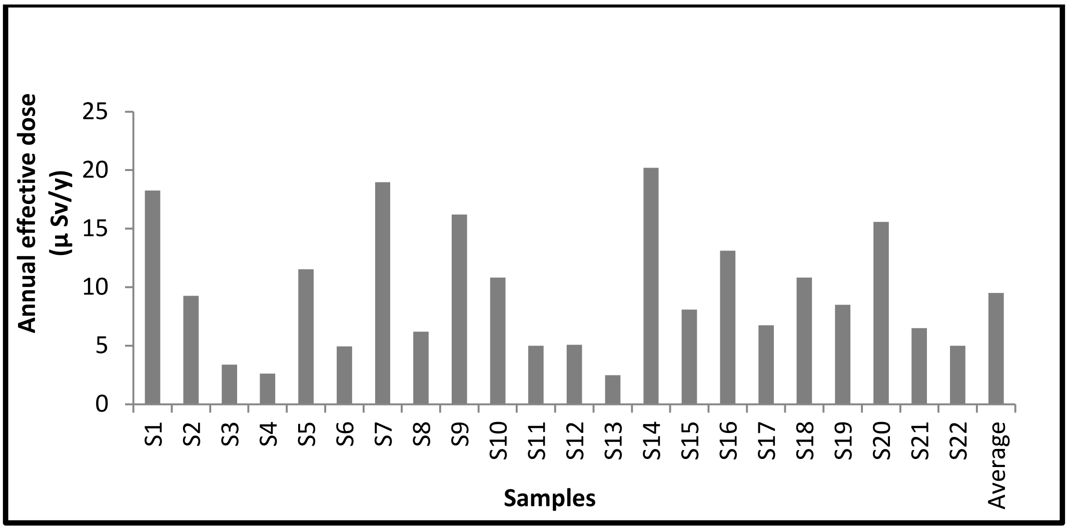


Figure 2: Annual radionuclides effective dose of the investigated oil samples , Saudi Arabia

5. Conclusion

This study showed the process of analyzing different samples of oil by using the high-purity germanium (HPGe) detector. The specific activity concentrations in (^{238}U, ^{232}Th and ^{40}K) are below the specific activity concentration of worldwide average. The estimated average annual effective dose is less than the annual dose limit of 1mSv reported in UNSCEAR 2000. Consequently, the results showed that all the used samples of this work are safe for the health, and do not create any significant source of radiation hazard. The current study will help in establishing a baseline of radioactivity exposure to the public.

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