Activity Concentrations and Mean Annual Effective Dose of Spices Food Consumed by Inhabitants of Saudi Arabia.

A.H. Al-Ghamdi

Physics Department, Faculty of Science, king AbdulAziz University, Jeddah, Saudi Arabia
aalgamdi5@kau.edu.sa

Abstract: The natural radionuclides 226Ra, 232Th and 40K were measured in Fourteen different spices food collected randomly from different markets in Jeddah city, Saudi Arabia by using gamma ray spectrometry. The activity concentration of 226Ra varied between 6.08±0.30 (*Nankhah*) to 105.02±4.517 Bq kg^{-1} (*Cloves*) with an average value 44.02 Bqkg$^{-1,}$ 232Th varied between 3.02±0.26 (Indian *Circuit*) to 124.23±7.55 Bqkg^{-1} (Cloves) with an average 30.97 Bqkg^{-1} and 40K varied between 229.95±1.8 Bqkg^{-1} in (White pepper*) to* 1116.56±9.6 Bqkg^{-1} in (Cloves) with average 605.84 Bqkg^{-1}. The total effective dose ranged from 5.63µSv y^{-1} in Nankhah *to 64.92*µSv y^{-1} in Cloves *with a* mean value of 23.26 µSv y^{-1}, all these values are less than the world total dose value 290 µSv y^{-1} for all foods reported by UNSCEAR *2*000. This study could be useful as a baseline data for radiation information of Saudi Arabia. The baseline data of this type will almost certainly be of importance in making estimations of populations exposure.

[A.H. Al-Ghamdi. **Activity Concentrations and Mean Annual Effective Dose of Spices Food Consumed by Inhabitants of Saudi Arabia.** *J Am Sci* 2014;10(11):164-168]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 22

Keywords: Natural radioactivity, Ingestion dose

1. Introduction

Study of natural radioactivity is usually done in order to gain information about the present levels of harmful pollutants discharged to the environment itself or in the living creatures UNSCEAR 2000. The naturally occurring radionuclides especially 40K and the radionuclides of 238U and 232Th series are the major source of natural radiation exposure to man. It has been estimated that at least one eighth of the mean annual effective dose due to natural sources is caused by the consumption of foodstuff (Ekdal; 2003). So, the knowledge of the concentrations and distributions of the radionuclides in human diet are of interest, since it provides useful estimation of possible radiological hazards to human health. Also, this type of work allows establishing baseline values for comparison with future measurements. Several studies have been performed in different countries to determine the radionuclides concentration indifferent food samples and dose assessment from consumption of that foodstuff by the population (Hosseini *et al.,* 2006, Nasreddine *et al.,* 2008, Shanthi *et al.,* 2010, Awudu *et al.,* 2012, James *et al.,* 2013). In this study, a radioactivity measurement in fourteen different types of food spices including Fennel, Anise, Nankhah, Black bean, Sweet condiment, Ginger, Coriander, Indian Circuit, Egyptian Circuit, Black pepper, White pepper, Bay leaf, Cloves and Cinnamon which are commonly available and consumed in Saudi Arabia. The assessment of the ingested radionuclides via food consumption was also made. This study is considered a part of the radiological baseline information of Saudi Arabia. Additionally, this type of work allows establishing baseline values for comparison with future measurements.

2. Materials and Method

2.1 Samples collection and preparation

A total of Fourteen spices food samples representing different types (local and imported), including Fennel, Anise, Nankhah, Black bean, Sweet condiment, Ginger, Coriander, Indian Circuit, Egyptian Circuit, Black pepper, White pepper, Bay leaf, Cloves and Cinnamon were collected randomly from different markets in Saudi Arabia (Jeddah City) between 2012-2013. Table (1) summaries the different spices foods were studied in this work. This table, also, indicates whether the food samples were imported or locally produced in KSA region. The samples were oven dried at 100^{o}C for approximately 12 h and prepared into powder form for analysis (IAEA; 1989). The prepared samples were weighed and were stored in tight plastic containers for four weeks to allow radioactive equilibrium to be reached between parents and their daughter radio nuclides, (IAEA; 1989). Detection and measurements of the radio nuclides in the powdered samples were carried out by gamma ray spectrometer using a NaI (TI) detector 3x3 inch with a 1024-chanel computer analyzer. The detector has a peak efficiency of 1.2x10^{-2} at 1332.5 Kev Co-60and an energy resolution (FWHM) of 7.5% for 662kev. Samples were accounted 23hours, the activity concentration of

Pb214 (352Kev) and Bi214 (609 Kev, 1120Kev) were chosen to provide an estimate of 226Ra, while that of the daughter radionuclides Pb212 (239Kev) Ac228 (911Kev) were chosen as indicator of 232Th. The specific activity of 40 K was directly measured using its single photo peak at 1460 KeV emitter.

2.1.2 Calculation of the activity concentration

The activity concentrations of the natural radionuclides in the measured samples were computed using the following relation (Noorddin; 1999, El taher; 2011):

$$A_S(Bqkg^{-1}) = C_a/\varepsilon_r M_s \qquad (1)$$

Where As is the activity concentration, C_a is the net gamma counting rate (counts per second), ε the detector efficiency of the specific γ–ray, P_r the absolute transition probability of Gamma–decay and M_s the mass of the sample (kg).

3. Results and discussions

3.1Activity concentrations of ^{226}Ra, ^{232}Th and ^{40}Kin the spices food

Fourteen samples food spices consumed in Saudi Arabia from different markets in Jeddah city investigated for 226Ra, 232Th and 40K are presented in Table 1. The concentrations of 226 Rain the Spices food samples ranged from 6.08±0.30Bqkg^{-1} in (*Nankhah*) to 105.022±4.52 Bqkg^{-1} in (Cloves) with an average value 44.02 Bqkg^{-1}, for 232Th concentration ranged from 3.02±0.26Bqkg^{-1} in (Indian *Circuit*) to 124.23±7.55 Bqkg^{-1} in (*Cloves*) with an average 30.97 Bqkg^{-1} and finally for 40K concentration ranged from 229.95±1.8 Bqkg^{-1} in (White pepper) to1116.56±9.6 Bqkg^{-1} in (Cloves) with an average 605.84 Bqkg^{-1}, respectively. ^{40}K was detected in all Spices food samples with reasonable activity concentration levels. The concentration of potassium was found to be very high compared to radium and thorium, this possibly due to the concentrations of 40K in the soil. Potassium is a micronutrient and it may be expected that the soil characteristics favor the mobilization of potassium and its subsequent migration into the plant (Pietrzak Flis; 2001). However, 40K is an essential biological element and its concentration in human tissue is under close metabolic control(UNSCEAR 1982). Fig(1) represents the activity concentrations of the three radionuclide 226Ra, 232Th and 40K in Spices food consumed in Saudi Arabia.

3.2 Estimation of Annual effective dose from ingested spices foods

Radiation doses to population from intake of radio nuclides in foods can be calculated from the Formula reported in Reference (UNSCEAR, 2000) :

Deff(Sv/y) = A C R …………………… (2)

Table 1. Radioactivity concentrations in different spices food samples Collected from local market inJeddah city, Saudi Arabia

No.	Spices food	Origin	Activity concentration (Bq kg^{-1} dry weight)		
			226Ra	232Th	40K
1	Fennel	Egypt	16.49±0.75	24.92±1.55	786.02±6.7
2	Anise	Saudi Arabia	38.21±1.66	37.44±2.28	964.81±15.8
3	Nankhah	Yemen	6.08±0.30	8.51±0.517	317.99±2.7
4	Black Bean	Saudi Arabia	73.07±3.63	18.21±1.11	369.55±3.8
5	Sweet condiment	Saudi Arabia	18.10±0.87	23.58±1.44	705.501±6.1
6	Ginger	Saudi Arabia	50.96±2.20	51.47±3.14	696.26±5.9
7	Coriander	Saudi Arabia	68.99±3.12	58.07±3.56	589.63±5.1
8	Indian Circuit	Indian	17.34±0.75	3.02±0.26	422.11±3.6
9	Egyptian Circuit	Egypt	51.49±2.25	34.56±2.11	510.95±4.4
10	Black pepper	Saudi Arabia	21.37±0.92	3.31±0.20	446.13±3.4
11	White pepper	Saudi Arabia	42.94±1.85	11.89±0.73	229.95±1.8
12	Bay leaf	Saudi Arabia	11.36±0.49	11.91±0.73	720.48±6.2
13	Cloves	Saudi Arabia	105.02±4.52	124.23±7.55	1116.56±9.6
14	Cinnamon	Saudi Arabia	94.79±4.71	22.47±1.36	730.67±6.2
Average value			44.02	30.97	605.84

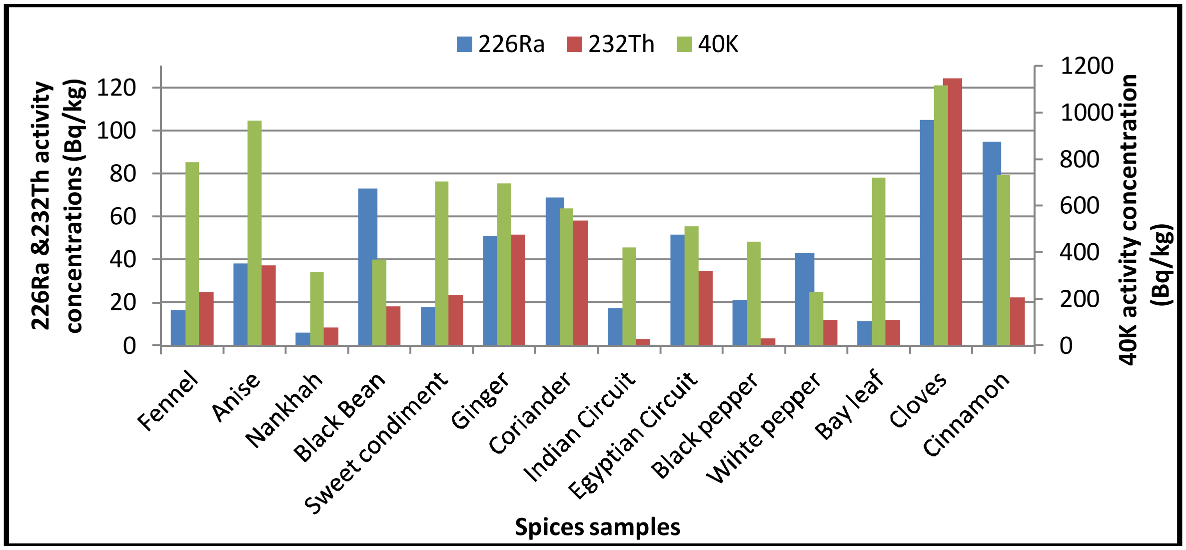

Fig1.Activity concentrations of 226Ra, 232Th and 40K in Spices food, Saudi Arabia

Where: **Deff** is the effective dose by ingestion of the radionuclide (SvY^{-1}),**A**is the activity concentration of the radionuclides in the sample ($Bqkg^{-1}$), **C** is the internal dose conversion factor by ingestion of the radionuclides ($Sv\ Bq^{-1}$) as 2.8×10^{-7}, 2.3×10^{-7} and 6.2×10^{-9} $Sv\ Bq^{-1}$ of 226Ra, 232Th and 40K, respectively, (ICRP 1995), **R** is the annual intake of food ($Kg\ Y^{-1}$) which depends on a given age. In this study, the consumption values for imported and locally produced spices foods are correspond to those of an adult person, the scale of the annual intake (1kg/year) UNSCEAR 2000. The risk associated with an intake of radionuclides in the body is proportional to the total annual internal dose delivered by the radionuclides.

Table (1) represents the annual effective dose of 226Ra, 232Th, 40K radionuclides and the total dose due to the three radionuclides in Saudi Arabia Spices foods samples were estimated and compared with the reported global dose due to ingestion of naturally occurring 226Ra, 232Th, 40K radionuclides UNSCEAR (2000). From Table 1, we can indicate the flowing :-

1-The annual effective ingestion doses due to intake of 226Ra varied from 0.64μSv y^{-1} in *Nankhah* to 29.41 μSvy^{-1} in Cloves. Most samples show highly significant increases in their ingestion doses over the values reported by UNSCEAR, 2000, with percentage increases ranging from 89 % (*Nankhah*) to 466 % (Cloves) of the value 6.3 μSv/y reported by UNSCEAR, 2000.

2 **-**The dose received from 232Th due to consumption of spices varied from 0.69 μSv y^{-1} in (*Indian Circuit)* to 28.58 μSv y^{-1} in (Cloves) which constitute 181.58 % (*Indian Circuit*) to 7518.42% (Cloves) of the total ingestion dose (0.38 μSv/y) as reported by UNSCEAR, 2000.

3 **-**The values of effective dose from ingestion of 40K ranged from 1.43μSv y^{-1} in (*White pepper) to* 6.92μSv y^{-1} in (Cloves). Thus, the contribution to dose from the ingestion of 40K in Spices food, with its relatively low dose conversion factor (6.2×10^{-9} $Sv\ Bq^{-1}$), will be much less than that of the other radionuclides. So, we can say that the high radionuclide intake was not due to high radionuclide concentration but due to the consumption rate. *It can be seen that the dose for* all samples are much lower than the dose value (170 μSv y^{-1}) for all foods reported by UNSCEAR 2000.

4 **-**The mean annual effective dose of 226Ra, 232Th and 40K in Saudi Arabia's Spices samples were estimated to be 12.32 μSvy^{-1}7.12 and3.81μSv y^{-1}, respectively. The highest mean annual internal dose was for 228Ra, all these mean doses are less the than annual dose limit of 1m Sv or general public (UNSCEAR*2*000, IAEA 2005).

5-The report UNSCEAR *2*000 shows that the sub-total ingestion dose of 238U and 232Th series is given by (120μSv y^{-1}) which is higher than the sub total dose for the results reported in this study for 226Ra and 232Th. This difference comes from 210Po, 210Pb and 228Ra, which are not considered in our measurements.

6 **-**The total effective dose ranged from 5.63μSv y^{-1} in (*Nankhah) to 64.91* μSv y^{-1} (Cloves) *with a* mean value of 23.26 μSv y^{-1}, where all these values are much less than the world total food dose value 290μSv y^{-1} for all foods as given by UNSCEAR *2*000. The low values of effective dose due to intake of spices is due to the low of the annual intake (1 kg/year) when compared with a few hundred kilograms per year for the total food intake. The relative contribution to the total dose due to 226Ra was 53%, followed by the contribution due to ^{232}Th and ^{40}K as 31%, 16 %, respectively. The relative contribution of naturally occurring radionuclides to effective dose in this study is presented in Fig. 2.

4. Excess lifetime cancer risk (Rc)

The risk incurred by a population is estimated by assuming a linear dose-effect relationship with no threshold as per ICRP practice. For low doses ICRP fatal cancer risk factor is 0.05 Sv^{-1}(ICRP1990). The risk factor states the probability of a person dying of cancer increases by 5% for a total dose of 1 Sv received during his lifetime. Therefore, the probability of death from cancer due to 'natural incidence' increases from about 25% to 30% following a total lifetime exposure of 1 Sievert. To estimate cancer risk for an adult person using the following relationship (Rafat and Fawzia; 2013, El-Taher and Alzahrani; 2014):

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

where :- RF is risk factor (Sv^{-1}), fatal cancer risk per Sever. For stochastic effects, ICRP 60 uses values of 0.05 for the public (ICRP, 1990). Cd is the life time effective dose which is a measure of the total effective dose received over an average lifetime of 50 y following ingestion of a radionuclide was calculated using UNSCEAR2000 :-

$$Cd = 50 \times D \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where D is the total effective dose to an individual.

Table 2, shows the calculated cancer risk values due to spices ranged from 0.14×10^{-4} to $1.62 \times 10^{-4}$with an average of 0.58×10^{-4}. This average value is comparable with other kinds of health risks which gives a risk factor of 0.48×10^{-4} due to spices food (Rafat and Fawzia; 2013).The present estimated values cancer is lower than the world average (2.9×10^{-4}) UNSCEAR; 2000, based on annual dose limit of 1 mSv for general public.It is therefore concluded that the average 23.26 μSvy^{-1} annual radiation dose attributable to spices intake of the three naturally occurring radionuclides (radium, thorium and potassium) in Saudi Arabia would not pose any significant.

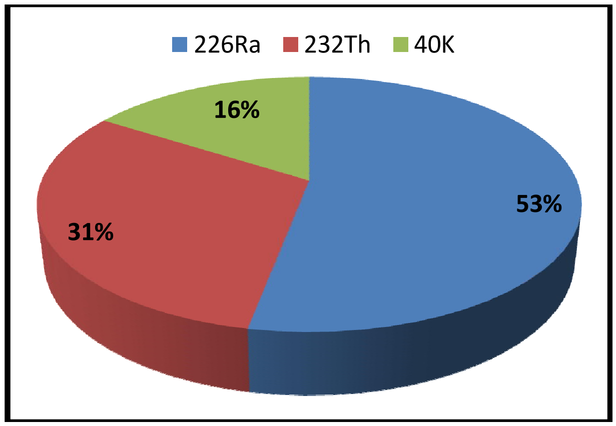

Fig. 2 Percentage contributions of radionuclides of interest to annual effective dose

Table 2. Annual radionuclide effective dose,total effective ingestion dose and Cancer risk due intake of 226Ra, 232Th and 40K radionuclides in the Spices food by adult population in Saudi Arabia

Spices food samples code	Annual radionuclide effective dose (µSv/y)			Total effective dose (µSv/y)	Cancer risk $\times 10^{-4}$
	226Ra	232Th	40K		
Fennel	4.62	5.73	4.87	15.22	0.38
Anise	10.69	8.61	5.91	25.21	0.63
Nankhah	1.70	1.96	1.97	5.63	0.14
Black Bean	20.46	4.19	2.29	26.94	0.67
Sweet condiment	5.07	5.42	4.37	14.86	0.37
Ginger	14.27	11.84	4.32	30.43	0.76
Coriander	19.32	13.36	3.66	36.34	0.91
Indian Circuit	4.86	0.69	2.62	8.17	0.20
Egyptian Circuit	14.42	7.95	3.17	23.54	0.64
Black pepper	5.98	0.76	2.77	9.51	0.24
White pepper	12.02	2.73	1.43	16.18	0.41
Bay leaf	3.18	2.74	4.47	10.39	0.26
Cloves	29.41	28.58	6.92	64.91	1.62
Cinnamon	26.54	5.17	4.53	36.24	0.91
Average	12.32	7.12	3.81	23.26	0.58
UNSCEAR2000	6.3	0.38	170	290	2.9

Conclusion

The study estimated the activity concentration of radionuclides 226Ra, 232Th, 40K by means of gamma ray spectrometry in different Spices food that are regularly consumed by the population of Saudi Arabia. The mean values activity concentration of 226Ra, 232Th and 40K in Saudi Arabia's Spices samples were 44.02 $Bqkg^{-1}$, 30.97 Bqkg-1and 605.84Bqkg-1 respectively. The maximum concentrations of 226Ra, 228Th and 40K were found in Cloves *sample to be* 105.022±4.52 $Bqkg^{-1}$, 124.23±7.55 $Bqkg^{-1}$ and, 1116.56±9.6 $Bqkg^{-1}$ respectively. The total annual effective doses received by members of the public from Spices food ranged from 5.63µmSv/y (*Nankhah*) to 64.91µmSv/y (Cloves), with a an average of23.26µmSv/y which gives a cancer risk factor of 0.0.55× 10^{-4}.The estimated risk has no significant health hazard and the studied spices samples are radiologically safe, as per international standards.

References

1. Awudu A.R.. Faanu A. Darko E. O. Emi-Reynolds G. Adukpo, O. K. Kpeglo D. O. Otoo F. Lawluvi H. Kpodzro R., Ali I. D,Obeng M. K., Agyeman B.; Preliminary studies on 226Ra, 228Ra, 228Th and 40K concentrations in foodstuffs consumed by inhabitants of Accra metropolitan area, Ghana, J Radioanal Nucl Chem (2012) 291:635–641
2. James, B. N. Dileep, R. M. Mulla, R. M. Joshi, M. S. Vishnu, P. D. Nayak, P. M. Ravi and P. K. Sarkar; Evaluation of international dose to members of the public at the Kaiga site, India, due to the ingestion of primordial radionuclide 40K, Radiation Protection Dosimetry (2013), Vol. 153, No. 1, pp. 56–63.
3. Ekdal E (2003);Investigation of 210Po and 210Pb radionuclides in agricultural soils and crops due to the use of phosphate fertilizers. Master's Thesis of Science, Izmir.
4. Hosseini T, Fathivand AA, Abbasisiar F, Karimi M, Barati H(2006). Assessment of annual effective dose from 238U and 226Ra due to consumption of foodstuffs by inhabitants of Tehran city,Iran. Radiat Prot Dos.
5. International Atomic Energy Agency(2005) Derivation of activity concentration values exclusion, exemption and clearance. In: Safety Report Series, Vol.44, IAEA, Vienna, Austria, pp. 1020-6450.
6. International Atomic Energy Agency. Measurement of radionuclides in food and the environment, a guide book.Technical Report Series 295 (Vienna: IAEA) (1989).
7. International Commission on Radiological Protection (ICRP (1995).Age-Dependent Doses to Members of the Public from Intake of Radionuclides: Part 3, Ingestion Dose Coefficients. ACRP Publication 69, Annals of the ICRP 25(3/4). Pergamon Press, Oxford.
8. El-Taher A. &J. H. Al-Zahrani[1], Radioactivity Measurements and Radiation Dose Assessments in Soil of Al-Qassim region, Saudi Arabia, Indian journal of apure and applied physics, (2014), Vol.52, pp147-154.
9. El-Taher, A. 2011 Terrestrial gamma radioactivity levels and their corresponding extent exposure of environmental samples from Wadi El Assuity protective area, Assuit, Upper Egypt. Journal of Radiation Protection Dosimetry 145 (4): 405-410.
10. Nasreddine, O. El Samad, N. Hwalla, R. Baydoun, M. Hamze´ and D. Parent-Massin3; Activity concentrations and mean annual effective dose from gamma- emitting radionuclides in the Lebanese dite, Radiation Protection Dosimetry (2008), Vol. 131, No. 4, pp. 545–550.
11. Rafat M. Amin and Fawzia Ahmed, Estimation of annual effective dose to the adult Egyptian population due to natural radioactive elements in ingestion of spices, Pelagia Research Library Advances in Applied Science Research, 2013, 4(5):350-354.
12. Shanthi G., Thampi Thanka Kumaran, Allan GnanaRaj G., GManiyan;Natural radionuclides in the South Indian foods and the irannual dose, Nuclear Instruments and Methods in Physics Research A 619 (2010) 436–440.
13. United Nations Scientific Committee on the effects of Atomic Radiation, Ionization Radiations: Sources and Biological Effects,1982, United Nations, New York.
14. United Nations Scienti®c Committee on the Effects of Atomic Radiation. UNSCEAR 2000. Report to General Assembly, pp. 93±156 (New York: United Nations) (2000).
15. Pietrzak Flis Z, Rosiak L, Suplinska MM, Chrzanowski E, Dembinsk S (2001) Daily intake of 238U, 234U, 232Th, 230Th,228Th and 226Ra in the adult population of Central Poland. Sci Total Environ 273:163–169.

10/25/2014