Iran. J. Radiat. Res., 2006; 4 (3): 149-153

Assessment of radionuclides in imported foodstuffs in Iran

T. Hosseini*, A.A. Fathivand, H. Barati, M. Karimi

Nuclear Science and Technology Research Institute, Material Research School, National Radiation Protection Department, Tehran, Iran

Background: Knowledge of radioactivity levels in human diet is of particular concern for the estimation of possible radiological hazards to human health. However, very few surveys of radioactivity in food have been conducted in Iran; therefore the baseline values of the natural radionuclides concentration (^{40}K, ^{226}Ra and ^{232}Th), and man made radionuclide, ^{137}Cs, were determined in twenty six samples of imported foodstuff in Iran. ***Materials and Methods:*** Twenty six samples of different kinds of imported foodstuff were selected for analysis. These samples, after pretreatment and washing (if necessary), were measured by a low level gamma spectrometry system. ***Results:*** All samples were found to contain detectable ^{40}K content in range 6.4 to 778.4 Bq.kg^{-1} fresh weights (fw). ^{137}Cs, ^{226}Ra and ^{232}Th were detectable in most of the samples. The maximum concentration of ^{40}K, ^{226}Ra and ^{232}Th were found in tea sample, equal to 778.4±23.4, 2.9±0.1 and 5.4±0.2 Bq.kg^{-1} (fw), respectively, where as for ^{137}Cs it was 3.2±0.1 Bq.kg^{-1} (fw) in milk powder. ***Conclusion:*** The concentrations of ^{40}K and ^{137}Cs in different imported foodstuff are comparable with those from the other countries yet ^{232}Th concentration is higher than the reported values. Also, ^{226}Ra results appear to be higher than the reported values in some cases. **Iran. J. Radiat. Res., 2006; 4 (3): 149-153**

Keywords: *Natural and man made radionuclides, imported foodstuffs, activity concentration, gamma spectrometry.*

INTRODUCTION

Foodstuffs are known to contain natural and man made radionuclides which after ingestion, contribute to an effective internal dose. The naturally occurring radionuclides especially ^{40}K and the radionuclides of ^{238}U and ^{232}Th series are the major source of natural radiation exposure to the 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 [1].

Man made radionuclides, produced by human activities also contribute to the environmental radioactivity, and one of these important radionuclides of environmental concern, is ^{137}Cs [2].

For contamination assessment of the foodstuff consumed by the population, it is very important to know the baseline value, or the level of radiation dose of both natural and synthetic radionuclides received by them.

Some researches have performed on determination of different radionuclides concentration in Iranian food samples, and dose assessment from consumption of that foodstuff by the population [3].

The aim of this study has been to investigate the concentrations of some long-lived radionuclides in imported foodstuff in Iran. These concentrations can be useful as baseline values for the estimation of the internal radiation dose.

MATERIALS AND METHODS

Twenty six samples of eleven kinds of imported foodstuff were selected for analysis. The sample types and their origins are listed in table 1.

Beef and chicken samples were washed, and the non-edible parts were removed. They were weighed and freeze dried. After drying, the samples were homogenized, and due to indirect measurement of ^{226}Ra and ^{232}Th, 500g, each sample was packed in a marinelli beaker, and sealed for four weeks to reach the radioactivity equilibrium between parents

***Corresponding author:**
Tahereh Hosseini, Nuclear Science and Technology Research Institute, Material Research School, National Radiation Protection Department, P.O. Box 14155, Tehran, Iran.
Fax: *+98 21 88009502*
E-mail: *thosseini@aeoi.org.ir*

Table 1. Concentration of radionuclides in different imported foodstuffs in Iran (Bq.kg-1 fresh weight) (± Uncertainty).

No	Sample	Country	^{40}K	^{137}Cs	^{226}Ra	^{232}Th
1	Beef	Brazil	111.0±3.3	0.085±0.013	0.054±0.008	0.088±0.044
2	Beef	Brazil	106.0±3.2	0.071±0.010	0.094±0.019	0.142±0.024
3	Chicken	France	52.4±2.6	0.083±0.013	0.675±0.115	0.195±0.053
4	Rice	Pakistan	31.7±1.0	0.019±0.007	0.112±0.016	0.073±0.015
5	Rice	Pakistan	49.6±1.5	0.026±0.016	0.042±0.020	0.056±0.031
6	Rice	Pakistan	45.0±1.4	0.040±0.013	0.054±0.011	0.086±0.016
7	Rice	Thailand	22.2±0.9	0.081±0.015	0.217±0.065	0.204±0.061
8	Rice	Thailand	22.8±1.1	<0.012	0.575±0.063	<0.027
9	Rice	Pakistan	7.1±0.4	<0.012	0.134±0.021	<0.026
10	Rice	Iraq	37.6±2.6	<0.012	<0.018	<0.027
11	Milk powder	Germany	610.0±18.3	3.202±0.096	0.064±0.018	0.094±0.027
12	Milk powder	New Zealand	605.5±12.1	0.828±0.025	0.149±0.034	0.147±0.037
13	Milk powder	New Zealand	549.0±16.5	1.600±0.048	0.186±0.035	0.166±0.032
14	Milk powder	France	434.1±13.0	0.123±0.016	0.05±0.011	0.142±0.026
15	Baby food	Belgium	42.4±0.8	<0.012	0.141±0.023	<0.023
16	Barley	Germany	124.6±2.5	<0.013	0.432±0.048	<0.037
17	Wheat	France	146.3±7.3	<0.014	0.570±0.057	<0.035
18	Wheat	Kazakhstan	99.4±2.0	<0.014	1.100±0.176	<0.035
19	Corn	USA	87.0±2.6	0.075±0.013	0.210±0.057	0.195±0.055
20	Corn	USA	9.3±0.5	<0.013	0.147±0.025	<0.035
21	Tea	Sri-Lanka	778.4±23.4	2.892±0.087	2.893±0.116	5.387±0.161
22	Tea	India	577.0±17.3	1.660±0.049	2.760±0.304	3.420±0.445
23	Tea	Sri-Lanka	628.0±18.84	2.010±0.181	2.550±0.459	2.270±0.454
24	Tea	India	374.2±7.5	0.628±0.056	0.566±0.051	1.700±0.136
25	Butter	Netherlands	6.4±0.3	0.180±0.022	0.298±0.080	0.826±0.149
26	Sugar	Germany	1.7±0.4	<0.016	0.158±0.047	0.140±0.073

and their daughter radionuclides.

Tea, butter and sugar samples without any pre-treatments were sealed in a marinelli beaker. The other samples were ashed in a muffle in 300°C for 6 hr after grinding and weighing. Then, 350g of washed samples were packed and sealed in a marinelli beaker.

All samples were measured by a gamma spectrometry system, manufactured by Canberra, using a High Purity Germanium (HPGe) detector with 40% relative efficiency. The detector was shielded by 10 cm lead on all sides, with cadmium-copper in the inner sides. The measurement time for each sample was 250,000 s.

Spectrum analysis was performed by the spectran-AT V.4.3 software. The selected characteristic gamma peaks for the detection of different radionuclides were 609 keV for ^{226}Ra (^{214}Bi), 583 keV for ^{232}Th (^{208}Tl), 661 keV for ^{137}Cs and 1460 keV for ^{40}K.

Efficiency calibration of the gamma spectroscopy system was performed by a marinelli standard mixed source (CERCA HM395) purchased from France. The minimum detectable activity (MDA) was approximately 12.2, 22.9, 11.7 and 182 mBq.kg^{-1}(fresh weight, fw) for ^{226}Ra, ^{232}Th, ^{137}Cs and ^{40}K respectively.

RESULTS AND DISCUSSION

The measured activity concentrations of ^{40}K, ^{137}Cs, ^{226}Ra and ^{232}Th in different imported foodstuff, including their uncertainty, are summarized in table 1.

In order to compare our results with the results from other countries, the activity concentrations of the same foodstuff in different countries are presented in table 2.

^{40}K content was measurable in all samples.

Table 2. Concentration of radionuclides in foodstuffs in different countries (Bq.kg^{-1} fresh weight).

Country	Sample	^{40}K	^{137}Cs	^{226}Ra	^{232}Th	Ref.
Reference value	Meat products	-	-	0.015	0.001	1
Reference value	Grain products	-	-	0.080	0.003	1
Reference value	Milk products	-	-	0.005	3×10^{-4}	1
Brazil	Beef	80.0	<0.04	<0.10	-	2
Brazil	Chicken	53.5	<0.07	<0.17	-	2
Brazil	Bean	434	<0.29	1.43	-	2
Brazil	Rice	14.7	<0.04	<0.11	-	2
USSR	Butter	-	14	-	-	4
USSR	Meat	-	6	-	-	4
Spain	Beef	130.0±10.4	<0.11	3.1±0.8	-	5
Spain	Chicken	14.0±0.3	<0.47	2.9±0.3	-	5
Venezuela	Milk Powder	401.7±32.1	1.55±0.4	-	-	6
Hong Kong	Beef	84.0±2.1	0.13±0.03	<0.020	<0.06	7
Ukraine	Beef	62.0±3.1	140.00±1	-	$1.2\times10^{-3}\pm1.1\times10^{-4}$	8
Ukraine	Vegetables	90.1±2.1	20.60±0.2	-	$0.006\pm1.8\times10^{-4}$	8
Ukraine	Milk	43.7±0.5	53.70±1.4	-	$3.9\times10^{-3}\pm1.6\times10^{-5}$	8
Hong Kong	Beef	91.0	0.12	0.006	-	9
Hong Kong	Chicken	76.0	0.07	0.006	-	9
Hong Kong	Rice	15.0	0.26	0.006	-	9
India	Tea	453.3-1024.1		0.320-3.632		10
Syria	Cereal*	56-382	-	-	-	11
Brazil	Chicken	-	-	0.057	0.031**	12
Brazil	Beef + pork	-	-	0.019	0.107**	12
Brazil	Milk	-	-	0.108	0.028**	12
England	Rice	-	-	<3.7×10-3-0.067	-	13
FAO/WHO guideline levels	Foodstuffs	-	1000	-	-	13

* Activity based on Bq.kg^{-1} dry weight.

** Activity of ^{228}, ^{232}Th.

Table 2 (Cont.). Concentration of radionuclides in foodstuffs in different countries ($Bq.kg^{-1}$ fresh weight).

Country	Sample	^{40}K	^{137}Cs	^{226}Ra	^{232}Th	Ref.
England	Meat	-	-	0.014	-	13
England	sugar	-	-	0.024	-	13
England	Tea	-	-	0.005-15	-	13
Taiwan	Rice	-	-	0.08±0.002	-	14
Taiwan	Chicken	-	-	0.17±0.007	-	14
U.S.A	Rice	-	-	$0.007\pm1.4\times10^{-4}$	$1\times10^{-4}\pm1.3\times10^{-4}$	15
U.S.A	Dry beans	-	-	0.057±0.003	0.027±0.002	15
U.S.A	Meat	-	-	$0.002\pm3.2\times10^{-4}$	$0.002\pm1.8\times10^{-4}$	15
Japan	Rice	-	-	-	$4.6\times10^{-4}\pm6.4\times10^{-5}$	16
Japan	Sugars	-	-	-	$1.6\times10^{-3}\pm1.6\times10^{-5}$	16
Japan	Bean products	-	-	-	$2.9\times10^{-3}\pm1.8\times10^{-4}$	16
Japan	Meats	-	-	-	$4.0\times10^{-4}\pm2.2\times10^{-5}$	16
Japan	Beans, animals and fish products	-	-	-	0.002	17
Japan	Grains	-	-	-	0.001	17
Brazil	Corn	-	-	0.119	-	18
European communities	Baby foods	-	400	-	-	19
European communities	Dairy products	-	1000	-	-	19
European communities	Liquid food	-	1000	-	-	19
European communities	Other foods	-	1250	-	-	19

^{137}Cs, ^{226}Ra and ^{232}Th contents were measurable in most of the samples.

The highest concentrations of ^{40}K, ^{226}Ra and ^{232}Th were found in tea sample to be equal to 778.4, 2.9 and 5.4 $Bq.kg^{-1}$(fw), respectively. Also the lowest concentration of ^{40}K was found 6.4 $Bq.kg^{-1}$(fw) in the butter sample. The lowest concentration of ^{226}Ra and ^{232}Th were found 42.2 and 56.5 $mBq.kg^{-1}$ in rice sample, respectively.

The highest ^{137}Cs concentration was obtained in milk powder to be equal to 3.2 $Bq.kg^{-1}$ (fw). The minimum detected concentration of ^{137}Cs was found 26.4 mBq.kg-1 in rice sample.

The concentrations of ^{40}K and ^{137}Cs in the mentioned imported foodstuff were less than, or comparable with those from other countries [4-9, 11], except for ^{40}K concentration in milk powder and rice [2, 6] which were higher.

The ^{226}Ra concentrations appeared to be higher than the reported values in beef, chicken, rice and sugar [2, 7, 9, 10, 12-15]. Also, the obtained results have been higher than the values which reported as reference values in

UNSCEAR [1].

The ^{232}Th concentrations in some foodstuff (beef, chicken, rice and sugar) are higher than the reported values in different articles [7, 8, 15-17], as well as the reference value [1].

In addition, the results of man-made radionuclides concentration in imported foodstuff can be used by the authorized governmental agencies to compare those concentrations with permissible limits. In general, foods with radionuclides concentration more than permissible limits are not permitted to be importated.

ACKNOWLEDGEMENT

The authors would like to extend their gratitude to Mr. H. Tajik-Ahmadi from Nuclear Safety and Protection Technology Center of Iranian Nuclear Regulatory Authority for his assistance in supplying imported foodstuff.

REFERENCES

1. UNSCEAR (2000) United Nations Scientific Committee on the Effects of Atomic Radiation, Sources and effects of ionizing radiation, vol. 1, New York, United Nations Publication.
2. Venturini, L and Sordi, GAA (1999) Radioactivity in and Committed effective dose from some Brazilian foodstuffs. *Health Phys, **76**: 311-313.*
3. Hosseini T, Fathivand AA, Abbasisiar F, Karimi M, Barati H (2006) Assessment of annual effective dose from ^{238}U and ^{226}Ra due to consumption of foodstuffs by inhabitants of Tehran city, Iran. *Radiat Prot Dos, doi:10.1093/rpd/ncl030.*
4. Cooper EL, Zeiller E, Ghods-Esphahani A, Makarewicz M, Schelenz R, Findik O, Heilgeist M, Kalus W (1992) Radioactivity in food and total diet samples collected in selected settlements in the USSR. *J Environ Radioactivity, **17**: 147-157.*
5. Hernandez F, Hernandaz-Arams J, Catalan A., Fernandez-Aldecoa JC, Landeras MI (2004) Activity concentrations and mean annual effective does of foodtuffs on the island of Tenerife, Spain. *Radiat Prot Dos, **111**: 205-210.*
6. LaBecque JJ, Rosales PA, Carias O (1992) The preliminary results of the measurements of environmental levels of ^{40}K and ^{137}Cs in Venezuela. *Nucl Instrum and Methods in Phys Res, **A312**: 217-222.*
7. Mao SY and Yu KN (1995) Measurement of Natural and artificial radionuclide Concentrations in meat consumed in Hong Kong. *Radiat Measurements, **24**: 201-205.*
8. Shiaishi K, Tagami K, Ban-nai T, Yamamoto M, Muramatsu Y, Los IP Phedosenko GV, Korzun VN, Tsigankov NT, Segeda II (1997) Daily intakes of ^{134}Cs, ^{137}Cs, ^{40}K, ^{232}Th and ^{238}U in Ukrainian adult males. *Health Phys, **73**: 814-819.*
9. Yu KN and Mao SY (1999) Assessment of radionuclide Contents in food in Hong Kong. *Health Phys, **77**: 686-696.*
10. Lalit BY and Ramachandran TV (1985) Natural radioactivity in Indian tea. *Rad Environ Biophysics, **24**: 75-79.*
11. Al-Masri MS (2004) Natural radionuclides in Syrian Diet and their dairy intake. *J Radio anal Nucl hem, **2**: 405-412.*
12. Amaral ECS, Rochedo ERR, Paretzke HG, Franca EP (1992) The radiological impact of agricultural activities in an area of high natural radioactivity. *Radiat Prot Dos, **45**: 289-292.*
13. Department of the Environment (1993) HMIP-Commissioned research Natural radionuclides in environmental media. *DoE Report NO: DoE/HMIP/RR/93/063.*
14. Kuo YC, Lai SY, Huang CC, Lin YM (1997) Activity Concentrations and population dose from radium-226 in food and drinking water in Taiwan, *Appl Radiat Isot, **48**: 1245-1249.*
15. Fisenne IM, perry PM, Decker KM, keller HW (1987) The daily intake of ^{234}, ^{235}, ^{238}U, ^{228}, ^{230}, ^{232}Th and ^{226}, ^{228}Ra by New York city residents. *Health Phys, **53**: 357-363.*
16. Shiraishi K, Tagami K, Muramastu Y, Yamamoto M (2000) Contributions of 18 food categories to intake of ^{232}Th and ^{238}U in Japan. *Health Phys, **78**: 28-36.*
17. Shiraishi K and Yamamoto M (1995) Dietary ^{232}Th and ^{238}U intakes for Japanese as obtained in a market basket study and contributions of imported foods to internal doses. *J Radioanal Nucl Chem Articles, **196**: 89-96.*
18. Vasconcellos LMH, Amaral ECS, vianna ME (1987) Uptake of ^{226}Ra and ^{210}Pb by food crops cultivated in a region of high natural radioactivity in Brazil. *J Environ Radioact, **5**: 287-302.*
19. Woodman RFM, Nisbet AF, Penfold JSS (1997) Options for the management of foodstuffs contaminated as a result of a nuclear accident. (NRPB-R295) European Communities.