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Assessment of Natural Radionuclides in Powdered Milk Consumed in Iraq

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Abstract:
The activity concentrations of ^{226}Ra^{232}Th, and ^{40}K radionuclides were measured for 10 brands of powdered milk samples consumed in Iraq,which are imported from different countries.The main detected activity corresponding to ^{40}K with average activity of 290.661 BqKg^{-1}, while the average activities of ^{226}Ra and^{232}Th were below the detection level (B.D.L.).Results are compared with those of different countries worldwide.The total average annual effective doses due to intake of ^{40}Kfrom the ingestion of the powdered milk for children (2-7, 7-12, 12-17)y and adults ($\geq$ 17y) were estimated to be82.21, 50.90, 29.75 and 22.55 μSvy^{-1}, respectively. These results indicate no significant radiation dose to the public. The resulting data may serve as base-line levels of activity concentration in powdered milk in the area of study.
Keywords: Natural Radioactivity, Milk, Ingestion dose, Hazard quotient.

Introduction

Measurements of radioactivity in environment and in foodstuffs are extremely important for controlling radiation levels to which mankind is directly or indirectly exposed. Besides natural radionuclides, due to several nuclear weapon tests and numerous nuclear reactor accidents, various artificial radioactive elements were introduced in the biosphere. Another important fact is that, importation of contaminated food from any region that suffered a nuclear accident can be indirectly affect people health around the world (Melquiades&Appoloni, 2002).

The radio nuclides enter the human body mainly by two routes inhalation and ingestion,(Licata et al., 2004).Radionuclides sources on human diet are come mainly from milk, meat and other products more frequently consumed. Powdered milk, is an important ingredient used to make cookies, ice cream, yogurt, chocolate, powdered chocolate and many others human aliments. Also milk is one of the important food for human nutrition and contains all the macronutrients namely protein, carbohydrates, fat, vitamins (A,D and B groups) and trace elements particularly calcium, phosphate, magnesium, zinc and selenium, (Abollinoet al.1998; Buldini et al., 2002). In addition ^{40} K is one of the most important natural radio nuclides, because it is an essential constituent of cellular tissue.So, the assessment of radioactivity levels in the powdered milk and the associated doses are of crucial importance for controlling the radiation levels and necessary in establishing rules and regulations relating to radiation protection (Quindos et al., 1994).

The concentration of the natural radioactivity in food is often in the range of 40 to 600 Bq/kg of food. The radioactivity from potassium alone may be typically 420 Bq/kg in milk powder(IAEA 2002). Ramachandran and Mishra(1989) found that the concentrations of ^{40}K, ^{226}Ra and^{228}Th radioactivity in different foods varies from 45.9 to 649.0 Bq/kg,0.01 to 1.16 Bq/kg and 0.02 to 1.26 Bq/kg, respectively.

The aim of this study was to investigate the concentrations of some long-lived radio nuclides (^{226}Ra, ^{232}Th and ^{40}K) in the powdered milk consumed in Iraq,as well as, estimation of the annual internal dose from the intake of natural isotopes. These measurements can be useful as baseline values for the estimation of the internal radiation doses.

Material and Methods

Ten samples of different brands of powdered milk imported from different countries were collected from the local Iraqi markets, Baghdad. Commercial names and code of the milk samples are listed in Table (1). Detection and measurements of the radionuclides in the powdered samples were carried out using Gamma spectrometer (Canberra) system.Avertical high purity germanium (HPGe) detector of efficiency 40 % and resolution (2.0 KeV) was used. The total energy resolution was 1.85KeV, for the 1332KeV gamma line emitted from Co-60 source. The detector is coupled to a standard nuclear electronics associated with Multichannel analyzer (MCA) with 8192 channels.Both high voltage supply and amplifier device are compact in one unit (DSA 2000).The germanium crystal is located inside the lead shield (10 cm thick), lined inside with graded absorber of Cd ~ 1.6 mm and Cu ~ 0.4 mm.Marinelli beakers of 1 liter size were used in the analyses of the samples. An empty beaker with the same geometry was measured to subtract the background.

1. Activity concentrations

The measured activity concentrations of ^{226}R, ^{232}Th and ^{40}K detected in the samples of powdered milk under study including their uncertainty are summarized in Table (1).It can be noticed that ^{40}K was detected in all samples and varied between 203.43±13.52Bqkg^{-1}to 355.88±17.67Bqkg^{-1} with an average value of

290.67±14.97Bqkg^{-1}. The highest value of ^{40}K were detected in sample M1 (Tahani from New Zealand), while,the lowest concentration was found in sample M4 (Carination, Nestle, Switzerland). On the other hand, the concentrations of ^{226}Ra and ^{232}Th were below the detection limit (B.D.L.). The obtained results were compared with thereported data in literature (Table 2).

2. Effective Dose Calculation

Estimation of the radiation induced health effects associated with the intake of radionuclide in the body is proportional to the total dose delivered by the radionuclide. Thus, the ingested effective dose can be calculated by multiplying the activity concentrations(Bq.kg^{-1}) by the amount of food consumed in a period of time (kg.y^{-1}), and then by effective dose coefficient(Sv.Bq^{-1}). This can be summarized in the following equation (UNSCEAR 2000):

$$D = C\ A\ R \qquad \ldots\ldots\ldots(1)$$

Where: D is the effective dose by ingestion of the radionuclide (Svy^{-1}),Ais the activity concentration of the radionuclides in the sample (Bqkg^{-1}), C is the effective dose coefficient for ingestion of the radionuclides (Sv Bq^{-1}) (see Table 3),R is the annual intake of milk (kg y^{-1}) which depends on a given age (ICRP 1996). Annual effective ingestion dose due to milk consumption strongly depends on the milk consumption. Conservatively estimated, Iraq consumes a minimum of 120,000 tons of powdered milk/year and possibly as much as 200,000 tons/year as reported by the USAID/IRAQ (2006).

In our study the average mass of the powdered milk consumed by the children (age from 2 to 7 y, 7to12y and from 12 to 17 y) and adults (age from 17 y and above) of 14Kgy^{-1} and 13Kgy^{-1}, respectively, (UNSCEAR,1993 ; Zaid et al 2009) . Table 4 shows the calculated annual effective doses due to the intake of ^{40}Kin the reconstituted powdered milk for different age groups. The results showed that the average annual effective dose due to the intake of the natural radionuclide ^{40}K due to the ingestion of the powdered milkfor children (2-7, 7-12, 12-17)y and adults (≥ 17y) were estimated to be 82.2150.90, 29.75 and22.55µSvy^{-1}, respectively. These results for all ages are within the typical world wide range of annual dose (200–800 µSv) due to the ingestion of all natural radiation sources (UNCEAR2000).

Conclusions

Natural radioactivity such as ^{226}Ra ,^{232}Th and ^{40}K radionuclides were determined for most available powdered milk consumed in Iraq. The main gamma activity arises from ^{40}K which was a detected value to be within the world wide ranges as reported in other regions around the world. ^{226}Ra and ^{232}Th activities were below the detection limits. In addition the annual effective internal dose due to the intake of powdered milk was calculated. The largest contributors to the dose received from ingestion of milk in general was due to natural radionuclides, particularly ^{40}K which was an essential constituent of cellular tissue.

^{40}K behaves in the environment the same as other potassium isotopes, being assimilated into the tissues of all plants and animals through normal biological processes. It is the predominant radioactive component in human tissues and in most food. For example, milk contains about 2000 pCi/L of natural ^{40}K (Baeza et al, 2004, Argonne National Laboratory, EVS 2005).

This radionuclide is one of the most important long-lived radionuclide on earth crust and its concentration in environmental samples can be an indicator for long-term radiation of this element because of its high solubility and ease of transfer. Considering the health physics limitations, the amount of effective dose calculated in this study (22.55µSvy^{-1}for adults) showed that the dose received by milk ingestion was too low to induce health hazards. The calculated effective dose for children varies between82.21 50.90 and 29.75 µSvy^{-1}for different ages. This was not critical too but the variation mainly referred to the varieties in consumption rate.

Finally, although the investigation showed no significant hazard, the obtained data was so useful to be used as a database.

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Table(1):Activity concentrations (Bq/Kg) of different radionuclides present in powdered milk samples investigated in present work

Code No.	Samples	country of origin	^{226}Ra	^{232}Th	^{40}K
M1	Tahani	New Zealand	B.D.L.	B.D.L.	355.88±17.67
M2	Five cows	New Zealand	B.D.L.	B.D.L.	257.57±14.97
M3	Incolac	Belgium	B.D.L.	B.D.L.	331.31±12.09
M4	Carination, Nestle	Switzerland	B.D.L.	B.D.L.	203.43±13.52
M5	Al-Mudhish	Oman	B.D.L.	B.D.L.	303.69±11.54
M6	Dielac	Vietnam	B.D.L.	B.D.L.	263.14±15.41
M7	Halibna	Belgium	B.D.L.	B.D.L.	300.81±16.35
M8	Landoze	New Zealand	B.D.L.	B.D.L.	300.43±16.28
M9	Active boy	Holland	B.D.L.	B.D.L.	281.18±15.75
M10	Badeea	New Zealand	B.D.L.	B.D.L.	309.17±16.13
RANGE					203.43±13.52 - 355.88±17.67
AVERAGE					290.67±14.97

Table (2): Comparison of the average concentrations of 226Ra,232Th and 40K with those published data in powdered milk (Bqkg-1)

Region	^{226}Ra	^{232}Th	^{40}K	Reference
Iraq	-------	-------	203.43-355.88	Present work
Saudi Arabia	3.26 – 17.72 (9.64)	1.59 – 13.57 (6.77)	29.46– 146.33 (74.51)	Zain M.Alamoudi, (2013)
Iran/France	0.05	0.142	434	Hossein et al., (2006)
Brazil	----	1.7 – 3.7	489	Melquiades et al, (2002)
Indian	2.5	1.02	34.35	Shanthi et al (2010)
Egypt Alexandria	0.44	-----	47. 25	Ibrahim et al. (2007)
Syria	-----	----	129- -435	Al-Marsiet al.,(2004)
Jordan	0.5 --2.14	0.78--1.28	349 —392	Zaidet al.,(2010)

Table (3): Effective dose coefficients (e) for ingestion of radionuclides ^{226}Ra, ^{232}Th and ^{40}K for members of the public to 70 years of age.

Effective dose coefficients (nSv Bq^{-1})			
Age	^{226}Ra	^{232}Th	^{40}K
Children 2-7 Y	620	350	21
Children 7-12Y	800	290	13
Children 12-17Y	1500	250	7.6
Adults 17 Y	280	230	6.2

Table (4): Annual effective ingestion dose due to the intake of ^{40}K in powdered milk

Age	Ingestion dose (µSv y^{-1})		
	Min	Max	Ave
Children 2-7 Y	59.80	104.62	82.21
Children 7-12Y	37.02	64.78	50.90
Children 12-17Y	21.64	37.86	29.75
Adults 17 Y	16.40	28.69	22.55