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Annual effective dose and concentration levels of gross α and β in Turkish market tea

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Background: Tea is one of the most popular beverages all over the world which is prepared from the leaves of a shrub camellia sinensis. Eastern Black Sea Region of Turkey which account for around 100% of all tea production in Turkey was among the areas contaminated by Chernobyl accident. ***Materials and Methods:*** A comprehensive study was planned and carried out to determine the level of gross α and β radioactivity and annual effective dose equivalent in different Turkish market tea using LSC. ***Results:*** The average measurements for digestion and infusion are 5.0 $mBql^{-1}$ and 1.8 $mBql^{-1}$ for gross α, 80.7 $mBql^{-1}$ and 9.0 $mBql^{-1}$ for gross β in tea samples. Contributions of the infusion tea samples to total annual effective dose equivalent from ^{238}U, ^{234}U, ^{230}Th, ^{226}Ra, ^{210}Po, ^{232}Th, ^{238}Th, ^{210}Pb and ^{228}Ra are 0.103, 0.112, 0.480, 0.640, 2.742, 0.525, 0.164, 7.740 and 7.740 μSvy^{-1} for adults. ***Conclusion:*** The obtained results showed that natural activity concentrations of α- and β-emitting radionuclides and annual effective dose equivalent in tea samples did not exceed WHO recommended levels. **Iran. J. Radiat. Res., 2012; 10(2): 67-72**

Keywords: *Gross α, gross β, activity, tea, effective dose equivalent.*

INTRODUCTION

Tea is one of the most popular beverages all over the world which is prepared from the leaves of a shrub camellia sinensis. Green and black teas are the two most popular types. Drying and roasting the leaves produces green tea, black tea is obtained after a fermentation process. Economic and social interest in tea is clear from the fact that about 18–20 billion tea cups are consumed daily in the world [(1,2)]. China is the world's largest tea producer, respectively, in this country, India, Sri Lanka, Kenya, Turkey, Indonesia and Japan followed. Tea production in Turkey is about 200,000 $tonsyear^{-1}$, %30 of which is exported for a total annual revenue of 5-8 million US$. Eastern Black Sea Region of Turkey which account for around 100% of all tea production in Turkey was among the areas contaminated by Chernobyl accident [(3)]. ^{137}Cs was remained in the ecosystems many years after the accident. The levels of ^{137}Cs activity concentrations in Turkish tea plants were found to be the maximum value of 44 $kBqkg^{-1}$ for the products[(4)]. The medicinal value of tea for prevention and treatment of many health problems has become more and more commonly known [(5)]. Tea contains flavonoids, minerals and trace elements that are essential to human health.

Environmental radiation originates from a number of naturally occurring and man-made sources. The largest proportion of human exposure to radiation comes from natural sources of external radiation, including cosmic and terrestrial radiation and from inhalation or ingestion of natural radioactive materials. The United Nations Scientific Committee on the Effects of Atomic Radiation has estimated that exposure to natural sources contributes >70% of the population radiation dose and the global average human exposure from natural sources is 2.4 $mSvy^{-1}$ (cosmic ray 0.4, terrestrial gamma ray 0.5, radon 1.2, and food and drinking water 0.3)[(6)]. Acute health effects of radiation, appearing with symptoms of nausea vomiting, diarrhea, weakness, headache, anorexia leading to reduced blood cell counts and in very severe cases to death,

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occur at high doses of exposure of the whole body or large part of the body. Therefore, acute health effects of radiation are practically not a concern for continuously monitored for radioactivity content–central drinking water supplies. However, extreme situations of possible terrorist use of radioactive materials to contaminate drinking water supplies, theoretically, cannot be excluded [7].

The dose arising from the intake of 1 Bq (by ingestion) of radioisotope in particular chemical from can be estimated using a dose conversion factor. Data for age related to dose conversion factors for ingestion of radionuclides has been published by the ICRP [8]. The dose conversion factors– synonyms are dose coefficients or dose per unit intake values ($mSvBq^{-1}$) – for naturally occurring radionuclides (detectable primarily at higher natural background radiation areas) or those arising from human activities that might be found in water supplies at somewhat higher probability (in case of incident)[7].

The radionuclides contributing significantly to the ingestion dose via consumption of water are ^{226}Ra, emitting alpha radiation, and ^{210}Pb, emitting beta radiation. ^{226}Ra is typical of the naturally occurring α emitting radionuclides of interest, and ^{90}Sr is among the man-made β emitters [9]. However, it is not always necessary to identify specific radionuclides when the concentrations are low. In such cases, measurements of gross α and gross β activities may serve to demonstrate that the radio toxicity level is acceptable. In particular gross alpha activity is a sensitive and immediate indicator of the concentrations of uranium isotopes and ^{226}Ra [10].

The recommendations do not differentiate between natural and man-made radionuclides. Below these reference levels of gross activity, drinking water is acceptable for human consumption and any action to reduce radioactivity is not necessary.

The main aim of this study is to determine the level of gross α and β radioactivity and annual effective dose equivalent in different Turkish market tea for public health in this 25-year period after the Chernobyl accident.

MATERIALS AND METHODS

Twenty nine marked brands of black tea (S1-S29) and one type of green tea (S30) which commonly consumed in Turkey were collected from local markets in January 2010.

Measurements of gross α and β activity concentrations in different tea samples were carried out by Liquid Scintillation Counter (LSC). In this experiment, Packard Tricarb 2770 TR-SL LSC was used. Liquid scintillation counting is a standard laboratory method for measuring radiation from beta-emitting nuclides.

The two methods commonly used for preparation of tea were adopted for this study to assess the actual amount of gross α and β activity reach human body through drinking such beverages. The two methods are:

Infusion: Tea infusion samples were prepared in a way which Turkish drinking habits are taken into account. In this method, 100 ml of hot distilled water was added to 2 g of black tea sample. The mixture left to cool at room temperature for 5 min and then filtered to obtain the clear solution for further processing.

Digestion: Portions of 0.50 g of each brand were digested using 10 ml of a mixture (2:1 v/v) of concentrated HNO_3 and HCl. The mixture was heated on sand bath until the solution turned into white color and gives out white fumes. The digest sample was filtered and transferred into 100 ml volumetric flask and the volume was adjusted 100 ml by adding distilled water.

Ultima Gold LS produced by Packard Instrument Company was used as the liquid scintillater because of the advantages of a commercial liquid scintillation counting system for determining gross α and β concentrations in different tea samples including small sample volumes, minimal sample preparation time and minimal operator attention.

In the present study, 241Am (alpha energy (MeV)—5.49(85%) and 5.44 (12%)) and 90Sr/90Y (beta energy (MeV) -0.55 (100%)/2.28(100%)) were used as an alpha and beta standards for calibrations, respectively.

Digestion samples were counted for 60 min by LSC. 3 ml of each sample was taken from stock solution and mixed with 15 ml Ultima Gold LS cocktail. The energy region from 30.0 to 350 keV is used for alpha measurements and from 0.00 to 185 keV for beta measurements. The results of the count rate were corrected regarding to SIS mode efficiency and correcting for counting in alpha and beta regions.

Infusion samples were counted for 300 min by LSC. 3 ml of each sample was taken from stock solution after being warmed for 5 min and optimized as Turkish habits and mixed with 15 ml Ultima Gold LS cocktail.

The net count rate is expressed for the total radioactivity for alpha and beta emitting radionuclides considering c/m = d/m considering the counting efficiency in both alpha and beta region is 100%.

The following equation was used to calculate the doses (11, 12).

$$DRw = Aw \times IRw \times IDF \qquad (1)$$

Where DRw annual effective dose equivalent (μSv year^{-1}), Aw gross α and gross β activities (mBql^{-1}), IRw intake of water for person in 1 year. The annual effective dose equivalents were assessed for Turkish people that drink 1250 cub of tea per year. Finally, the individual effective dose equivalents were assessed for adults who drink average 3.50 cup of tea per day (2 g leached in 100ml boiled water in each one cup).

The total indicative dose was calculated for adults using the following approach. IDF annual effective dose conversion factors (mSvBq^{-1}). The gross α activities were assumed to be from ^{238}U, ^{234}U, ^{230}Th, ^{226}Ra, ^{210}Po, ^{232}Th, respectively. The gross β activities were assumed to be from ^{210}Pb and ^{228}Ra. For our calculations, we used the following dose conversion factors published by the WHO (WHO, 2004): 4.50×10^{-5} mSvBq^{-1} for ^{238}U, 4.90×10^{-5} mSvBq^{-1} for ^{234}U, 2.10×10^{-4} mSvBq^{-1} for ^{230}Th, 2.80×10^{-4} mSvBq^{-1} for ^{226}Ra, 1.20×10^{-3} mSvBq^{-1} for ^{210}Po, 2.30×10^{-4} mSvBq^{-1} for ^{232}Th, 7.20×10^{-5} mSvBq^{-1} for ^{228}Th, 6.90×10^{-4} mSvBq^{-1} for ^{210}Pb, and 6.90×10^{-4} mSvBq^{-1} for ^{228}Ra.

RESULTS AND DISCUSSION

Activity concentrations of gross α and gross β and extract percent in aqueous for tea samples (digestion and infusion) are shown in table 1.

Concentrations ranging from 1.70 mBql^{-1} (S2) to 9.70 mBql^{-1} (S18) and from 11.10 mBql^{-1} (S27-S30) to 222.00 mBql^{-1} (S4) were observed for the gross α and gross β activities in digestion samples, respectively. Concentrations ranging from 0.60 mBql^{-1} (S11) to 5.50 mBql^{-1} (S19) and from 1.10 mBql^{-1} (S5) to 20.10 mBql^{-1} (S28) were observed for the gross α and gross β activities in infusion samples, respectively.

The average measurements for digestion and infusion are 5.00 mBql^{-1} and 1.80mBql^{-1} for gross α, 80.70 mBql^{-1} and 90.00 mBql^{-1} for gross β in the tea samples. It can be seen from table 1 that the gross β activity is always higher than the gross α activity. It was determined that total α and total β activity concentrations for all tea samples are lower than 0.1 Bql^{-1} for α and 1 Bql^{-1} for β which is WHO's recommendation(7).

The data presented in table 1 reveal the extract percent in aqueous of tea samples (S1-S29) and green tea sample (S30). The results show that the amount of gross α activity transferred from tea to the aqueous extract ranged from 6.30 to 91.30%. The amount of gross β activity transferred from tea to the aqueous extract ranged from 5.60 to 56.80%. These values are closed to reference values that have been published by Syrians and Egypt market tea samples (13, 14). Desideri have reported 19.30 Bqkg^{-1}

for ^{210}Po in tea samples from Italy. The percentage of ^{210}Po extraction in infusion was also determined; the arithmetical mean value of percentage of ^{210}Po extraction resulted 20.7±7.50 [15]. K. Salahel Din has recorded values of ^{210}Po concentration in tea samples were varied between 10±0.54 and 18.6±0.91 mBq g^{-1} dry wt from Egypt [16].

The calculated annual effective dose equivalents values for α and β emitters are presented in table 2.

Contributions of the infusion tea samples to total annual effective dose equivalent from ^{238}U, ^{234}U, ^{230}Th, ^{226}Ra, ^{210}Po, ^{232}Th, ^{238}Th ^{210}Pb and ^{228}Ra are 0.10, 0.11, 0.48, 0.64, 2.74, 0.53, 0.16, 7.74 and 7.74 µSvy^{-1} for adults. The results from this study indicate that the annual effective doses are below the WHO recommended reference level of 0.30 µSvy^{-1} for α and 0.20-0.80 µSvy^{-1} for β in food and drinking samples [7]. Lasheen *et al.* have reported mean to total

Table 1. Gross α and β activity concentrations and the extract percent in aqueous of all tea samples.

Samples	Total Gross Activity mBql^{-1} (digestion)		Total Gross Activity mBql^{-1} (infusion)		Percent of extract in infusion. %	
	Gross α	Gross β	Gross α	Gross β	Gross α	Gross β
S1	7.41±0.6	159.0±0.4	0.74±0.1	8.90±0.2	10.00	5.60
S2	1.70±0.2	29.60±0.2	1.48±0.1	7.41±0.2	87.10	25.00
S3	3.70±0.3	48.10±0.2	0.74±0.1	9.41±0.2	20.00	19.60
S4	3.90±0.3	222.0±1.1	1.38±0.1	14.0±0.3	35.40	6.30
S5	3.80±0.3	18.50±0.3	1.58±0.1	1.10±0.3	41.60	5.90
S6	4.70±0.3	211.0±2.4	1.48±0.1	12.0±0.2	31.50	5.70
S7	2.70±0.3	196.0±1.1	0.76±0.1	11.0±0.2	28.10	5.60
S8	3.70±0.3	18.50±0.2	2.48±0.2	1.30±0.2	67.00	7.00
S9	4.70±0.3	22.20±0.4	1.78±0.2	6.90±0.2	37.90	31.10
S10	4.30±0.3	29.60±0.9	1.46±0.1	7.80±0.2	34.00	26.40
S11	2.90±0.3	59.30±2.9	0.64±0.1	9.10±0.2	22.10	15.30
S12	4.80±0.3	115.0±4.6	1.48±0.1	9.80±0.2	30.80	8.50
S13	3.10±0.3	44.40±0.1	0.74±0.1	7.70±0.2	23.90	17.30
S14	7.40±0.6	77.80±0.3	1.39±0.1	10.10±0.2	18.80	13.00
S15	3.70±0.3	81.50±0.3	1.78±0.2	10.90±0.2	48.10	13.40
S16	6.70±0.3	204.0±0.6	1.47±0.2	13.70±0.2	21.90	6.70
S17	7.30±0.3	29.60±0.3	2.48±0.3	8.10±0.2	34.00	27.40
S18	9.70±0.1	33.30±0.3	3.47±0.1	8.90±0.3	35.80	26.70
S19	8.70±0.3	63.00±0.2	0.55±0.4	6.70±0.2	6.30	10.60
S20	4.30±0.3	59.30±0.2	1.97±0.3	6.40±0.2	45.80	10.80
S21	4.80±0.3	55.60±0.2	1.27±0.3	7.10±0.2	26.50	12.80
S22	2.70±0.3	85.20±0.3	0.94±0.1	9.20±0.3	34.80	10.80
S23	3.30±0.3	96.30±4.1	0.89±0.2	10.90±0.4	27.00	11.30
S24	9.30±0.3	119.0±4.7	4.47±0.5	12.30±0.4	48.10	10.30
S25	4.60±0.3	92.60±2.5	4.20±0.4	10.80±0.6	91.30	11.70
S26	5.40±0.3	100.0±4.2	1.47±0.2	9.40±0.5	27.20	9.40
S27	5.20±0.3	11.10±0.7	1.80±0.3	6.30±0.7	34.60	56.80
S28	3.70±0.3	111.0±4.1	1.70±0.2	20.10±0.8	45.90	18.10
S29	7.40±0.6	18.50±0.4	2.10±0.5	5.80±0.4	28.40	31.40
S30	3.50±0.3	11.10±0.7	1.20±0.3	6.10±0.7	34.30	55.00

annual effective dose equivalent from ^{238}U, ^{234}U, ^{230}Th, ^{226}Ra, ^{210}Po, ^{232}Th, ^{238}Th ^{210}Pb and ^{228}Ra are 1.20, 1.30, 49.00, 7.70, 6.30, 16.70, 60.70 and 60.70 μSvy^{-1} for different tea samples in Egypt(14). These values are higher than present study.

CONCLUSION

In this paper, a study of gross α and β radioactivity of one type of green tea, 29 kinds of black tea purchased from the local Turkish market is presented. Tea is one of the most popular beverages in the world. The Eastern Black Sea Region of Turkey is one of the main tea producers in Turkey and the fifth in the world. Thus, the radioactivity levels in tea have received great interest because they are related to health. Since this region was contaminated by the Chernobyl accident in 1986, a comprehensive study was planned and carried out to determine gross α and gross β levels in tea growing region. In terms of the market of samples for infusion, it is very important to determine the level of radioactivity values in these products to ensure consumer safety.

Table 2. The annual effective doses of alpha emitters in different tea samples (μSvy^{-1}).

Samples Number	Alpha Emitter (μSvy^{-1})							Beta Emitter (μSvy^{-1})	
	U-238	U-234	Th-230	Ra-226	Po-210	Th-232	Th-228	Pb-210	Ra-228
S1	0.04	0.05	0.20	0.26	1.11	0.21	0.07	7.68	7.68
S2	0.08	0.09	0.39	0.52	2.22	0.43	0.13	6.39	6.39
S3	0.04	0.05	0.20	0.26	1.12	0.21	0.07	8.12	8.12
S4	0.08	0.09	0.36	0.48	2.07	0.40	0.12	12.08	12.08
S5	0.09	0.10	0.42	0.55	2.37	0.45	0.14	0.95	0.95
S6	0.08	0.09	0.39	0.52	2.22	0.43	0.13	10.35	10.35
S7	0.04	0.05	0.20	0.27	1.15	0.22	0.07	9.49	9.49
S8	0.14	0.15	0.65	0.87	3.72	0.71	0.22	1.12	1.12
S9	0.10	0.11	0.47	0.62	2.67	0.51	0.16	5.95	5.95
S10	0.08	0.09	0.38	0.51	2.19	0.42	0.13	6.73	6.73
S11	0.04	0.04	0.17	0.22	0.96	0.18	0.06	7.85	7.85
S12	0.08	0.10	0.39	0.52	2.22	0.43	0.13	8.45	8.45
S13	0.04	0.05	0.20	0.26	1.12	0.21	0.07	6.64	6.64
S14	0.08	0.09	0.37	0.49	2.09	0.40	0.13	8.71	8.71
S15	0.10	0.11	0.47	0.62	2.67	0.51	0.16	9.40	9.40
S16	0.08	0.10	0.39	0.52	2.21	0.42	0.13	11.82	11.82
S17	0.14	0.15	0.65	0.87	3.72	0.71	0.22	6.99	6.99
S18	0.20	0.21	0.91	1.21	5.21	1.00	0.31	7.68	7.68
S19	0.31	0.34	1.44	1.92	8.21	1.57	0.49	5.78	5.78
S20	0.11	0.12	0.52	0.70	2.96	0.57	0.18	5.52	5.52
S21	0.07	0.08	0.33	0.45	1.91	0.37	0.11	6.12	6.12
S22	0.05	0.06	0.25	0.33	1.41	0.27	0.09	7.94	7.94
S23	0.05	0.06	0.23	0.32	1.34	0.26	0.09	9.40	9.40
S24	0.25	0.27	1.16	1.57	6.71	1.29	0.40	10.61	10.61
S25	0.24	0.26	1.10	1.47	6.30	1.21	0.38	9.32	9.32
S26	0.08	0.10	0.39	0.52	2.21	0.42	0.13	8.11	8.11
S27	0.10	0.11	4.73	0.63	2.70	0.52	0.16	5.43	5.43
S28	0.10	0.10	4.46	0.60	2.55	0.49	0.15	17.34	17.34
S29	0.12	0.13	5.51	0.74	3.15	0.60	0.19	5.00	5.00
S30	0.07	0.07	3.15	0.42	1.80	0.35	0.11	5.26	5.26
Mean	0.10	0.11	4.80	0.64	2.74	0.53	0.16	7.74	7.74

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