Food Control 22 (2011) 2065–2070

Contents lists available at ScienceDirect

Food Control

journal homepage: www.elsevier.com/locate/foodcont

Review

Radionuclides and heavy metals concentrations in Turkish market tea

Filiz Korkmaz Görür [a,*], Recep Keser [a], Nilay Akçay [a], Serdar Dizman [a], Nazmi Turan Okumuşoğlu [b]

[a] Rize University, Faculty of Sciences and Arts, Department of Physics, Rize 53100, Turkey
[b] Ondokuz Mayıs University, Faculty of Sciences and Arts, Department of Physics, Samsun, Turkey

ARTICLE INFO

Article history:
Received 17 March 2011
Received in revised form
27 May 2011
Accepted 7 June 2011

Keywords:
Tea
Radioactivity
Heavy metals
ICP/OES

ABSTRACT

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 chemical components 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 the radioactivity level in the tea growing region. The activity concentrations of ^{232}Th, ^{238}U, ^{40}K and ^{137}Cs were measured in 29 black tea and one green tea samples from local Turkish markets using gamma spectrometry with an HpGe detector. The average activity concentration of ^{232}Th, ^{226}Ra, ^{40}K and ^{137}Cs were found 3.2 ± 0.6 Bq/kg, 6.4 ± 0.7 Bq/kg, 445.6 ± 17.8 Bq/kg and 42.0 ± 1.4 Bq/kg in tea samples, respectively.

In addition, the concentration of five heavy metals including Fe, Mn, Zn, Cu and Pb were determined by inductively coupled plasma spectroscopy (ICP/OES) on tea samples. Among the investigated metals, Mn was the highest levels. The levels of manganese were in the range of 1850.75–292.65 μg/g (mean: 1286.35 ± 0.58 μg/g). Levels of Pb in the tea samples analyzed were below the detection limits. The concentrations of all elements for daily intake are below safety levels for human consumptions.

Contents

1. 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 (Marcos, Fischer, Rea, & Hill, 1998; Pedro, Martin, Pablos, & Gonzalez, 2001). 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 tons/year, %30 of which is exported for a total annual

* Corresponding author. Tel.: +90 464 223 61 26; fax: +90 464 223 53 76.
E-mail address: filizkorkmaz@yahoo.com (F. Korkmaz Görür).

0956-7135/$ – see front matter
doi:10.1016/j.foodcont.2011.06.005

revenue of 5–8 million US$. The Eastern Black Sea Region of Turkey which accounts for around 100% of all tea production in Turkey was among the areas contaminated by Chernobyle accident (TAEK, 1998). ^{137}Cs was remained in the ecosystems many years after the accident. The level of ^{137}Cs activity concentrations in Turkish tea plants was found to be the maximum value of 44 kBq/kg for the 1986 products (Gediklioğlu & Sipahi, 1989).

The medicinal value of tea for prevention and treatment of many health problems has become more and more commonly known (Naithani & Kakkar, 2005). Tea contains flavonoids, minerals and trace elements that are essential to human health. Current studies show that tea contains specific antioxidants and health promoting ingredients, lowering the risk of heart diseases, stroke and certain types of cancer like oral, pancreatic and prostate (Pedro et al., 2001). Tea drinking could be an important source of some essential minerals such as manganese, which activates numerous enzymes. The levels of manganese in other foods/beverages are relatively small. Owing to the great importance of the minerals present in tea, many studies have been carried out to determine their levels in tea leaves and their infusions. Various analytical techniques that have been used for this purpose include atomic absorption spectrometry (AAS), inductively coupled plasma atomic emission spectrometry (ICP-AES), inductively coupled plasma mass spectrometry (ICP-MS) and total reflection X-ray fluorescence spectrometry (TR-XRF) (Han & Li, 2002; Matsuura, Hokura, Katsuki, & Itoh, 2001; Narin, Colak, Turkoglu, Soylak, & Dogan, 2004; Xie, von Bohlen, Klockenkamper, & Jian, 1998). Determination of heavy metals in tea samples is important from two aspects; to judge their nutritional value and to guard against any probable ill-effect, they may cause to human health.

The aims of in this study are to determine activity concentrations of ^{232}Th, ^{238}U, ^{40}K and ^{137}Cs and five heavy metals including Fe, Mn, Zn, Cu and Pb in the 30 different market tea samples for public health in this 24-year period after the Chernobyl accident.

2. Materials and methods

2.1. Sample collection

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.

2.2. Radioactivity measurements

All the collected tea samples were ashed for 24 h and 450 °C. The ashed samples then were homogenized, weighed, and transferred into uncontaminated empty cylindrical plastic containers of uniform size. The samples were kept four weeks before the analysis at air tight condition to allow secular equilibrium between thorium and radium and their decay products.

The radiation levels of samples were analyzed using gamma spectrometry, which was equipped with a 55% efficiency high purity germanium (HPGe) detector and a multi-channel analyzer. The gamma spectra were analyzed by using the ORTEC Maestro 32 data acquisition and analysis system. The detector had coaxial closed-facing geometry with the following specifications: resolution full width half maximum (FWHM) at 122 keV ^{57}Co was 1.00 keV and at 1.33 MeV ^{60}Co was 1.90 keV. The detector was shielded by a cylindrical lead shield, which had average thickness of 10 cm to reduce the background due to the cosmic rays and the radiation nearby the system. Efficiency of the detector was determined with a ^{152}Eu source of known activity. ^{152}Eu source has been widely used for calibration and efficiency determination due to their large range of energies (122, 244, 344, 411, 443, 779, 964, 1112 and 1408 keV) with emission probabilities of 3–29% (Firestone & Shirley, 1998; Grigorescu et al., 2002). An ideal measuring geometry of cylindrical source (homogeneously distributed activity with constant volume and distance) was placed coaxially with the detector for the efficiency determination and the same procedure applied for the sample measurements.

For the measurement of ^{226}Ra activity concentration, the γ-ray energies of 295.21 and 351.92 keV of ^{214}Pb, 609.31 keV of ^{214}Bi were used. The activity concentration of ^{232}Th was determined at the γ-ray energies 911.07 keV and 969.11 keV of ^{228}Ac, ^{40}K and ^{137}Cs were measured directly from the 1460.8 keV and 661.66 keV peak energies, respectively (ICRP, 1990; IAEA, 1989).

Tea samples were placed symmetrically on top of the detector and measured for a period of 100.000 s. The net area under the corresponding peaks in the energy spectrum was computed by subtracting counts due to Compton scattering of higher peaks and other background sources from the total area of the peaks. From the net area of a certain peak, the activity concentrations in the samples were obtained using Eq. (1):

$$C\left(\mathrm{Bq\ kg^{-1}}\right) = \frac{C_n}{\epsilon P_y M_s} \tag{1}$$

where C is the activity concentration of the radionuclide in the sample given in Bq/kg, C_n is the count rate under the corresponding peak, ϵ is the detector efficiency at the specific γ-ray energy, P_γ is the absolute transition probability of the specific γ-ray, and M_S is the mass of the sample (kg).

2.3. Dose estimation

Effective dose is a useful concept that enables the radiation doses from different radionuclides and from different types and sources of radioactivity to be added. It is based on the risks of radiation induced health effects and the use of the International Commission on Radiological Protection (ICRP) metabolic model that provides relevant conversion factors to calculate effective doses from the total activity concentrations of radionuclides measured in foods (ICRP, 1990). Estimates of the radiation induced health effects associated with intake of radionuclides in the body are proportional to the total dose delivered by the radionuclides. Radiation doses ingested are obtained by measuring radionuclide activities in foodstuffs (Bq/kg) and multiplying these by the masses of food consumed over a period of time (kg/d or kg/y). A dose conversion factor (Sv/Bq) can then be applied to give an estimate of ingestion dose. Thus, according to ICRP (ICRP, 1996), the ingested dose is given by:

$$H_{T,r} = \sum (U_i C^r) g_{T,r} \tag{2}$$

where i denotes a food group, the coefficients U_i and C^r denote the consumption rate (kg/y) and activity concentration of the radionuclide r of interest (Bq/kg), respectively, and $g_{T,r}$ is the dose conversion coefficient for the ingestion of radionuclide r (Sv/Bq) in tissue T. For adult members of the public, the recommended dose conversion coefficients $g_{T,r}$ for ^{40}K, ^{226}Ra, ^{232}Th and ^{137}Cs are 6.2.9 $\times$ 10^{-9} Sv/Bq, 2.8 $\times$ 10^{-7} Sv/Bq, 7.2 $\times$ 10^{-8} Sv/Bq and 1.3 $\times$ 10^{-8} Sv/Bq, respectively (ICRP, 1996).

2.4. Heavy metal analysis

The heavy metals of samples were analyzed using inductively coupled plasma spectroscopy (ICP/OES). The two methods commonly used for preparation of tea were adopted for this study to assess the actual amount of heavy metal reach human body through drinking such beverages. The two methods are: