Food Chemistry 176 (2015) 193–196

Contents lists available at ScienceDirect

Food Chemistry

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

Estimated daily intake of Fe, Cu, Ca and Zn through common cereals in Tehran, Iran

S. Kashian *, A.A. Fathivand

Radiation Applications Research School, Nuclear Science and Technology Research Institute, Tehran, Iran

ARTICLE INFO

Article history:
Received 22 July 2014
Received in revised form 8 December 2014
Accepted 8 December 2014
Available online 16 December 2014

Keywords:
Cereals
Neutron activation analysis
Daily intake
RDA
Deficiency
Essential trace elements

ABSTRACT

This paper presents the findings of study undertaken to estimate the dietary intake of iron (Fe), copper (Cu), calcium (Ca) and zinc (Zn) through common cereals in Tehran, Iran. 100 samples of rice, wheat and barley were collected from various brands between August and October 2013. The samples were analyzed performing instrumental neutron activation analysis (INAA). The dietary intake for adults was estimated by a total cereal study. Calculations were carried out on the basis of the reported adults' average food consumption rate data. The total daily intake estimated in mg d^{-1} for Tehran population were 3.6 (Fe), 10.2 (Zn), 0.3 (Cu) and 234.5 (Ca). Wheat showed the highest contribution to Zn, Cu and Ca intakes. Furthermore, intakes were compared with recommended dietary allowance (RDA). Zn total intake (10.2 mg d^{-1}) was comparable with RDA values for males (11 mg d^{-1}) and was higher than recommended value for females (8 mg d^{-1}). The intakes of other studied elements were below the respective RDAs.

1. Introduction

Trace elements can be divided from a dietary point of view into three groups: the essential trace elements; the possibly essential trace elements and the non-essential trace elements (Underwood, 1997). Iron (Fe), calcium (Ca), copper (Cu), and zinc (Zn) are the most essential trace elements and minerals. The roles of the essential trace elements in human health and disease have been documented in the literature and the role of these trace elements play in human nutrition is of particular interest. Iron functions as a component of a number of proteins, including enzymes and hemoglobin. It is also necessary for growth, development, normal cellular functioning and synthesis of some hormones and connective tissue (Institute of Medicine, 2001; Solomons, 1998). The World Health Organization (WHO) estimates that approximately half of the 1.62 billion cases of anemia worldwide are due to iron deficiency in developing countries (Van Wouwe, 1995).

Copper has the main role in immune system, connective tissue and skeleton, blood formation, the blood vessels and nervous system. Zinc and copper are cofactors of the antioxidant enzyme, superoxide dismutase (Cu/Zn-SOD) which detoxifies the toxic superoxide radical (Catharine Ross, Taylor, Yaktine, & Del Valle, 2011; Çavdar et al., 2002).

Calcium is the most abundant mineral in the body. Calcium deficiency can also cause rickets, though they are more commonly associated with vitamin D deficiency.

Zinc is an essential mineral. The biological functions of zinc can be divided into three categories: catalytic, structural and regulatory (Cousins, 1996). Nearly 100 specific enzymes depend on zinc for catalytic activity (Institute of Medicine, 2001; Sandstead, 1994). Zinc also participates in certain enzymatic systems required for DNA and RNA syntheses and it seems to influence the proliferative response of normal human lymphocytes.

Recent studies show that, the deficiency of essential trace elements was considerable in population of Iran (Bahareh, Mahboob, Razavieh, & Ghaem Maghami, 2005; Navai, Kimiagar, Abolhasan zadeh, & Lashgari, 2010; Sedehi, Behnampour, & Golalipour, 2013). Therefore; estimation of daily dietary intakes of these elements through foods is of great importance. Cereals have the specific role in nutrition supply.

The overall estimates show that about 350 g of wheat, 115 g of rice and 5 g of barley are used daily by Iranian people (National Nutrition Research Institute Tehran-Iran, 2014). In this research, the concentrations of iron, calcium, copper and zinc were measured in wheat, rice and barley samples using instrumental neutron activation analysis (INAA). The results were compared by

* Corresponding author at: Atomic Energy Organization of Iran, Nuclear Science and Technology Research Institute, Radiation Applications Research School, End of North Karegar Ave, P.O. Box: 11365-3486, Tehran 1439951113, Iran. Tel.: +98 2188221222; fax: +98 2188221219.

E-mail address: skashian@aeoi.org.ir (S. Kashian).

http://dx.doi.org/10.1016/j.foodchem.2014.12.021
0308-8146/

other countries. At the end, these concentrations were used to estimate the total daily common cereal intakes by adults in Tehran.

2. Materials and methods

2.1. Sample preparation

20 different known commercial brands of cereals produced in Iran were purchased from local markets and supermarkets. Instrumental neutron activation analysis was employed to determine the concentrations of elements in the collected samples.

For elemental analysis, the samples were first washed in deionized water and dried at 80 °C until the sample's weight became constant. Then, the samples were ground to coarse powder, weighed and poured into a polyethylene container. For elemental analysis and verification of the analytical method, two standard reference materials IAEA-336 and V-10 supplied by International Atomic Energy Agency (IAEA), were chosen. The weight of the samples and standards ranged from minimum value of 404.92 mg and 96.17 mg to maximum values of 483.17 and 105.75 mg, respectively.

2.2. Irradiation and counting

Using pneumatic sample transfer system, the samples were irradiated along with two reference materials IAEA-336 and V-10 at Tehran research reactor. The thermal neutron flux utilized was about 3×10^{13} n cm^{-2} s^{-1}.

To determine short lived radionuclides, ^{49}Ca ($T_{1/2}$ = 8.72 m) and ^{66}Cu ($T_{1/2}$ = 5.10 m), the samples and standards were irradiated for 3 min and measured after 2 min of irradiation. The counting time was 500 s and the gamma ray transitions energies of 3084.54 keV and 1039.20 keV were used to determine ^{49}Ca and ^{66}Cu, respectively. For determination of long-lived radionuclides ^{59}Fe ($T_{1/2}$ = 44.5 d) and Zn ($T_{1/2}$ = 243.9 d), the samples and standards were irradiated for 2 h and were measured after 10 days decay times. The counting time was 10,000 s to obtain a spectrum with good statistics. The gamma ray transition energies of 1099.25 keV and 1115.55 keV were used to identify ^{59}Fe and ^{65}Zn, respectively.

2.3. Measurement system

Samples and standards were measured after irradiation using a shielded High Pure Germanium (HPGe) detector with an energy resolution of 2 keV at full width half of maximum (FWHM) from 1332 keV energy of ^{60}Co and relative efficiency of 10%.

The empty polyethylene container was also measured for subtraction of background if necessary. With the known quantity of each element in standard materials, the following equation could be used to calculate the concentrations of Fe, Cu, Ca and Zn in each sample through comparative method.

$$m_s = \frac{A(\text{net}_s)e^{-\lambda t_s}}{A(\text{net}_{st})e^{-\lambda t_{st}}} \times m_{st} \quad (1)$$

where $A(\text{net}_s)$ and $A(\text{net}_{st})$ are the sample and standard gamma ray net count rates (cps), λ is the decay constant of the radionuclide, t_s and t_{st} are cooling time of the sample and standard, m_s and m_{st} are masses of the elements (g) in the sample and standard, respectively. The daily intakes of Fe, Zn, Cu and Ca from each cereal item were estimated by multiplying the respective mean concentration in each cereal by the weight of that cereal consumed by an average individual from Tehran. Finally, the total dietary intake through cereals was obtained by summing these products for all cereals.

3. Results and discussion

3.1. Method validation

Measurement results for the concentration of interested elements in quality control sample Lichen IAEA-336 are listed in Table 1. From this table it was clear that the obtained values are in good agreement with the certified values. Therefore, to a great extent, this analytical technique could be used for reliable analysis of cereal samples.

3.2. Elemental concentrations and daily intakes

The concentration of the measured elements in rice, wheat and barley samples are compared in Table 2 with the data available in literature. The results show that barley is the richest dietary source of Fe (35.2 mg kg^{-1}) and Ca (671.6 mg kg^{-1}). The mean concentrations of Zn in studied cereals were close together and the highest Cu level (1.1 mg kg^{-1}) was detected in the rice samples.

As can be seen from Table 2, mean concentrations of Ca for rice samples are comparable with those from South Korea and Vietnamese (Jung, Yun, Lee, & Lee, 2005; Phuong, Chuong, Khiem, & Kokot, 1999). In all types of samples, Cu concentrations are lower than those reported from Pakistan, Iraq, Yemen and Spain (Al-Gahri & Almussali, 2008; Al-Jobori, Shihab, Jalil, Saad, & Mohsin, 1989; Depar, Rajpar, Memon, Imtiaz, & Zia-ul-Hassan, 2011; Hernández Rodríguez, Afonso Morales, Rodríguez Rodríguez, & Díaz Romero, 2011; Shar, Kazi, & Sahito, 2004). Fe concentration in our rice samples is higher than those values found in South Korea, USA and Vietnamese (Jung et al., 2005; Phuong et al., 1999; Wolnik et al., 1985) whereas the concentration of this element in wheat samples is lower than the data reported by researchers in Yemen and Spain (Al-Gahri & Almussali, 2008; Hernández Rodríguez et al., 2011).

Table 3 summarizes the data on daily consumption rate of 3 cereal types for adults, living in Tehran, as well as the dietary intake of Fe, Zn, Cu and Ca for this age group. From Table 3, it was evident that maximum intakes of Zn (7.7 mg d^{-1}), Cu (0.2 mg d^{-1}) and Ca (221.4 mg d^{-1}) were through wheat. Rice showed the highest contribution to Fe total intake and the lowest intakes of all measured elements corresponded to barley. Furthermore, the total intake of each element through consumption of rice, wheat and barley was compared with the recommended dietary allowance (RDA) for analyzed elements. For Fe the total intake represented 45% of the RDA (8 mg d^{-1}) for male (Institute of Medicine, 2001) adults and 20% of the RDA (18 mg d^{-1}) for female adults (Institute of Medicine, 2001). Zn total intake (10.2 mg d^{-1}) was comparable with RDA values (11 mg d^{-1}) 8 for male adults and was higher than recommended value (8 mg d^{-1}) for female (Institute of Medicine, 2001). Cu (0.3 mg d^{-1}) and Ca (234.5 mg d^{-1}) intakes were 33% and 23% of RDA values, respectively (Institute of Medicine, 2001, 2011).

Table 1
Measured and reported concentrations (mg kg^{-1}) of analyzed elements in quality control sample.

Element	Certified value	Measured value
Fe	430 ± 50	432 ± 59
Zn	30.4 ± 3.4	29.8 ± 3.9
Cu	3.6 ± 0.5	3.8 ± 0.6
Ca	NR*	NM**

* Not reported.
** Not measured.