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Selenium content in wheat and estimation of the selenium daily intake in different regions of Algeria

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HIGHLIGHTS

- ► Cereals and cereal products represent a staple food in Algeria.
- ► The objective of this study is to determine the Se intake in wheat produced locally.
- ► The concentration of Se in the wheat reflects the level of the Se in regional soils.
- ► The mean of Se daily consumption is close to the minimal WHO/FAO recommendation.

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ABSTRACT

In this work, we have measured the selenium content in wheat produced locally in eight different regions of Algeria from east to west, and we have established the annual consumption of selenium for five socio-professional categories. Instrumental neutron activation analysis is used. The selenium levels in wheat samples varied from 21 (Tiaret) to 153 μg/kg (Khroub), with a mean value about 52 μg/kg. The mean of selenium daily consumption from ingestion of wheat per person in the eight regions varied from 32 to 52 μg/day which is close to the minimal FAO recommendation.

1. Introduction

During the last 20 years researchers in different countries have been interested in selenium content in frequently consumed food (Dundar and Altundag, 2004; Choi et al., 2009; Sirichakwal et al., 2005; Tahtat et al., 2003). Selenium is an essential micronutrient for animal and human health, with antioxidant and anticancer effects (Rayman, 2002), the biochemical role of selenium is its function as part of the enzyme glutathione peroxidase which protects vital components of cells against oxidative damage (Stadtman, 1990), it has been demonstrated that the activity of the enzyme decreases markedly in response to dietary deficiency.

In humans, two diseases have been associated with severe endemic selenium deficiency: fatal congestive cardiomyopathy known as Keshan disease (Keshan Disease Research Group, 1979) and osteoarthropathy known as Kashin–Beck disease (Yao et al., 2011). Keshan disease is endemic in women and children, occurs in a geographic distribution covering localities from north-east to south-west China. This region is characterized by low selenium availability in soils and agricultural product. In China, systematic dietary supplementation with sodium selenite has eliminated a generally fatal congestive cardiomyopathy (Keshan Disease Research Group, 1979; Tan and Huang, 1991). Kashin–Beck disease has been detected in children aged 5–13 years in China and less extensively in south-east Siberia (FAO/WHO, 2002).

Selenium is not considered essential for plant growth, and plants do not control selenium uptake (Ellis and Salt, 2003). Consequently, selenium concentrations in plants reflect generally the concentration of selenium in soils (Hintze et al., 2001).

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There is presence of some native plants as Astragalus, Xylorhiza, and Stanleya, which are able to accumulate high internal concentrations of selenium more than 1000 mg/kg, they require the selenium for their growth and they develop only in high selenium concentration soils (Rosenfeld and Beath, 1964). Similar foods may have very different concentrations of selenium depending on the origin of the agricultural product. Thus, because similar foods may be grown in several locations, use of single database selenium concentrations may lead to erroneous conclusions (Hawkesford and Zhao, 2007).

In a previous study on selenium intake in foods ration in the region of Algiers (capital) (Tahtat et al., 2003), we have concluded that the Algerian population consumes cereals and cereal products especially semolina at high amounts, about 70% of the total consumption, the reason for which we proposed in this study a new approach for the determination of selenium intake in different geographic regions of Algeria for the five socio-professional categories namely (Private employers, High commissioned officers, Medium commissioned officers, commissioned officers and labourers) by measuring selenium in the wheat produced locally.

2. Materials and methods

2.1. Sampling

The most important types of grain cultivated in Algeria were sampled: hard wheat (varieties Mexicali 75, Waha and Vitron). Wheat and soil samples were collected from different regions where the production of wheat is very high. Eight geographic regions were selected, three in the western part and five in the eastern part, respectively: Tiaret, Khemis Milian, Saida, Guelma, Constantine, Khroub, Setif, Oum el Bouaghi. The grain samples were harvested during the summer. Samples were washed in de-ionized water and dried overnight at 60 °C, the dried samples were powdered, lyophilised and homogenised in high speed mill and stored in the sealed bottles sterilised by γ-ray irradiation using ^{60}Co at a dose of 25 kGy.

2.2. Instrumental neutron activation analysis

About 100 mg of the sample were sealed in quartz vials packed in aluminium containers and irradiated in the core of the reactor. Three samples of each wheat product together with two standards (whey powder, IAEA-155 & Animal blood IAEA-A13, in each selenium, the concentrations are, respectively, 0.064 and 0.24 mg/kg) were irradiated for a period of 06 h at a thermal neutron flux of 4.5×10^{13} n/cm^2 s, in the pneumatic tube facilities of Es-Salem research reactor. The accuracy of the Se measurements in soil samples has been evaluated by analyzing two IAEA soil reference materials: IAEA Soil-7 and IAEA lake sediment SL-1 together with the soil samples. After a period of time of 04 weeks cooling, the irradiated samples and standards were carefully transferred to other vials and reweighted. The γ-ray measurements were carried out with a high purity germanium detector with 1.9 keV of resolution for 1332 keV of ^{60}Co and 20% relative efficiency. Moreover, in order to reduce the background, the detector and the samples were placed in a shield of 8 cm thick old lead. The γ transition produced in the reaction of the neutron capture ^{74}Se (n, γ) ^{75}Se (γ-ray energy = 264.7 keV, $T_{1/2}$ = 120 days) were used to determine the concentration of selenium. This γ-ray is interfered with those at 264.8 keV of ^{75}Ge (half-life of 82.78 min) and 264.4 keV of ^{77}Ge (half-life of 11.30 h). These interferences were eliminated by long periods of cooling (four weeks) necessary for the decay of short-lived activation products. The line 264.7 keV coincides also with that at 264.1 keV of ^{182}Ta (half-life of 115 d), but this line cannot exist because its principal line 1221.3 and 1221.4 keV do not exist in our sample. The spectra are evaluated with the program Genie 2000.

2.3. Estimation of daily selenium intake

Cereals and cereal products especially semolina, pate, couscous and cereals grains represent a staple food and traditional dietary in Algeria. The selenium intake per day per regions and per socio-professional categories was estimated by combining these foods consumption data given by NOS (National Office for Statistic) with analytical values obtained for wheat selected as described before, added to daily selenium intake (without cereals and cereal products) obtained in previous study (Tahtat et al., 2003).

3. Results and discussion

3.1. Selenium in the wheat grain

Table 1 shows the results expressed as µg/kg of selenium in wheat grain samples collected from different geographic regions of Algeria. The selenium content of wheat grain samples from the studied areas ranged from 0.021 to 0.153 mg/kg, with an average value of about 0.052 mg/kg. The average value is compared with average concentrations of different countries. The lowest selenium level was found in Tiaret (western part of Algeria) and the highest one was found in Khroub located in eastern part of Algeria, these concentrations are important if we compare them to other regions. The selenium content of food varies depending on the content of the element in the soil where the plant was grown (Hartikainen, 2005). Seasonal variability and geochemical and climatological conditions may also affect the selenium content of wheat grain (Al-Saleh and Al-Doush, 1997; Reilly, 1993).

There is wide variation in wheat grain selenium level between and within countries. Values range from 0.001 mg/kg in southwest Western Australia (White et al., 1981) to 30 mg/kg in highly seleniferous areas of South Dakota. In Hungary selenium content in wheat ranged from 0.005 to 0.235 mg/kg (Alfthan et al., 1992). USA and Canada have relatively high concentration ranged from 0.2 to 0.6 mg/kg (Reilly, 2006). Greece has selenium content in wheat ranged from 0.12 to 0.29 mg/kg (Bratakos and Ioannou, 1989). Eastern Europe and New Zealand have generally low levels with an average of 0.028 mg/kg. Generally European wheat contains lower levels of selenium than North American wheat, Selenium levels of cereal grains produced in the Keshan disease area in China are as low as 0.003–0.007 mg/kg (FAO/WHO, 2002),

Table 1
Selenium content of wheat and soil.

States		Mean selenium content in wheat (µg/kg)	Coefficient of variation	Mean selenium content in soil (µg/kg)	Se (soil)/Se(wheat)
Western	Tiaret	21 ± 8	0.38	2210 ± 57	105 ± 7
	Khemis Miliana	60 ± 8	0.13	3882 ± 71	64 ± 9
	Saida	28 ± 9	0.32	2525 ± 63	90 ± 7
	Guelma	28 ± 7	0.25	2691 ± 55	96 ± 8
	Constantine	32 ± 11	0.34	3354 ± 67	104 ± 6
Eastern	Khroub	153 ± 49	0.32	6230 ± 101	40 ± 2
	Setif	34 ± 8	0.24	3169 ± 61	93 ± 8
	Oum el-Bouaghi	55 ± 5	0.09	3117 ± 58	56 ± 11

also in Scandinavian countries selenium content of wheat were ranged from 0.009 to 0.034 mg/kg (Kumpulainen, 1993), and for India ranged from 0.107 to 0.272 mg/kg (Yadav et al., 2008).

A large standard deviation (SD) (Tables 1 and 2) indicates that the data points are far from the mean and a small standard deviation indicates that they are clustered closely around the mean. The resulting coefficient of variation is an important measure of reliability as the standard deviation and mean comes from repeated measurements of single distribution. This situation could be taken as reference (CV reference = 0.33). In our study, the coefficient of variation was inferior to 0.33, the dispersion was less important and the variable values were clustered closely around the mean.

3.2. Daily consumption of selenium

We have established the daily consumption of selenium from ingestion of wheat in the different regions of Algeria for the five socio-professional categories on the basis of data given by NOS (National Office for Statistic, 2005). Our results were shown in Table 2 and enable us to make visual comparison of selenium daily contribution by regions which was shown in Fig. 1.

The highest daily consumption found was 59 μg/day and the lowest was 32 μg/day, and the average daily consumption was 43 μg/day. We observe the low daily consumption of selenium values in region of Tiaret where the selenium content in wheat was lower and the high daily intake of selenium values was in region of Khoub where the selenium content in wheat was higher. The dietary intake of selenium depends on its concentration in wheat and the amount of cereals and cereal products consumed.

Table 2
Main selenium daily consumption (μg/day) in the different regions of Algeria versus socio-professional category.

States	Class 1	Class 2	Class 3	Class 4	Class 5	Average ± SD
Tiaret	32	43	40	36	43	39 ± 5
Khemis Miliana	40	48	45	43	51	45 ± 4
Saida	34	44	41	38	45	40 ± 5
Guelma	34	44	41	38	45	40 ± 5
Constantine	34	44	41	38	45	40 ± 5
Khroub	47	53	51	51	59	52 ± 4
Setif	39	48	45	43	51	45 ± 5
Oum el- Bouaghi	37	46	43	41	48	43 ± 4

Class 1: private employers; Class 2: high commissioned officers; Class 3: medium commissioned officers; Class 4: workers; Class 5: labourers.

The National Office for Statistic, 2005 regrouped the population into five classes according to their standard of living (in this case to their consumer habit), namely: private employers, high commissioned officers, medium commissioned officers, workers and labourers. The daily intake of selenium of socio-professional categories versus regions showed that for private employers (Class 1) was the lower consumption ranged from 32 to 47 μg/day compared with the labourers (Class 5) where ranged from 43 to 59 μg/day which was higher consumption. For the high commissioned officers (Class 2), medium commissioned officers (Class 3) and workers (Class 4) where we observe relatively high values of selenium dietary intake ranged from 43 to 53 μg/day, 40 to 51 μg/day and 36 to 51 μg/day, respectively, because these socio-professional categories consumed high amount of cereals and cereal products.

The daily consumption of selenium recommended by US National Research Council to prevent pathological effects and considered to be necessary to support maximum expression of selenoenzymes activity is from 50 to 200 μg/day (Tahtat et al., 2003). The estimated selenium intake in different regions of Algeria ranged from 39 to 52 μg/day, this level was little close to the recommendation, just in the inferior limit edge. Comparing with selenium intake of other countries, namely Greece 39 μg/day (Pappa et al., 2006), Italy 51 μg/day (Amodio-Cocchieri et al., 1995), Sweden 44 μg/day (Becker and Kumpulainen, 1991), France 47 μg/day (Simonoff et al., 1988), Croatia 27 μg/day, New Zealand 19–80 μg/day, Japan 104–127 μg/day, Canada 98–224 μg/day (Combs, 2001), Australia 70–85 μg/day (Graham et al., 2003), California (USA) 107 μg/day, Maryland (USA) 132 μg/day Watkinson, 1974), Korea 57.5 μg/day (Choi et al., 2009) and Saudi Arabia 75–122 μg/day (Al-Ahmary, 2009), the Algerian falls is comparable with that calculated in European countries like Greece, Italy, Sweden and France and is considerably lower than that of the Japan, Canada, USA and Saudi Arabia.

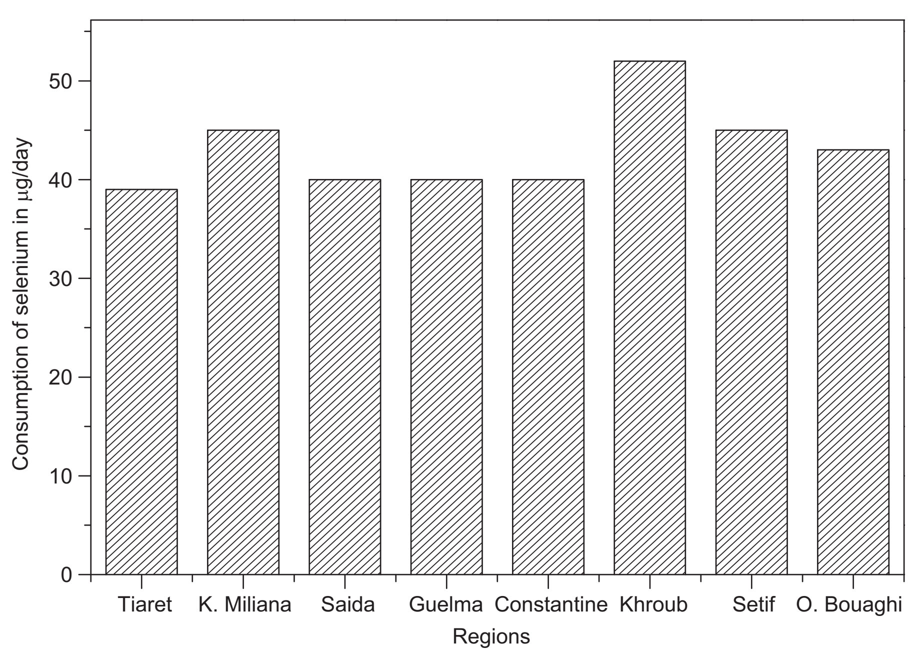

Fig. 1. Consumption of selenium in μg/day versus different geographic regions.

4. Conclusion

Selenium bioavailability depends not only on its total content in soil but also on its chemical form and soil properties such as aeration, contents of clay and organic matter. The concentration of selenium in the wheat shows higher variability and reflects the level of the selenium in regional soils (see Table 1). Cereal and cereal products as a staple food contribute in significant level of selenium to Algerian people. The daily consumption of selenium from ingestion of wheat per regions and per socio-professional categories ranged from 32 to 59 μg/day.

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