RESEARCH

Open Access

Survey of cadmium, lead, and arsenic in sesame from Iran

Niloofar Khoshtbakht Fahim, Hamed Reza Beheshti, Somayeh Sadat Fakoor Janati and Javad Feizy*

Abstract

Background: Sesame is one of the most consumed oilseeds in human food in the whole world. In various forms, it is used for the preparation of foods, cookies, cakes, and so on. This study was applied for the determination of lead, cadmium, and arsenic in 80 samples of sesame purchased from supermarkets in Khorasan province, Iran.

Results: The results showed that arsenic is one of the trace elements in crops (edible plants) with an average concentration of 54 ng g^{-1} , and three (3.75%) samples were above the maximum tolerated level of Pb in Iran (100 ng g^{-1}) regulations.

Conclusions: The results were obtained after complete digestion of these samples and determination using graphite furnace atomic absorption spectrometry and hydride generation atomic absorption spectrophotometry and indicate that 96.25% of the sesame samples could be suitable for human food.

Keywords: Sesame, Cadmium, Lead, Arsenic, AAS

Background

Sesame (*Sesamum indicum* L.) is one of the edible seeds in human foods in the whole world. Sesame is probably the most ancient oilseed cultivated in several countries such as India, Sudan, China, and Burma which are considered as the major producers (60% of its total world production) [1]. It is widely used as food in the Iranian kitchen and food sector.

Lead and cadmium are known as toxic elements. Both metals cause adverse health effects in humans, and their widespread presence in the human environment comes from anthropogenic activities [2]. These elements are not natural substances in nutrition [3]. Cadmium ions are easily absorbed by vegetables and in animal-based food and are principally distributed in the liver and kidneys. The highest cadmium concentrations are found in rice, wheat, oyster, mussels, and the kidney cortex of animals [4]. Lead is a well-documented metal toxicant, exposure of which leads to many fatal diseases, including the dysfunction of renal blood and neurological systems [5]. The effect of lead is actually similar to cadmium [6]. Arsenic is a ubiquitous element, introduced to the environment from natural and anthropogenic sources [7]. It

is known to be one of the most toxic elements and has serious effects on plants, animals, and human health [8]. Because of the possible health risk, it is very important to control the level of these toxic elements in food, especially in products, which are known to have beneficial effects on health.

In the analysis of heavy metals in plant materials and food samples, atomic absorption spectrometry (GFAAS, FAAS) is reported most frequently [9]. Other techniques such as inductively coupled plasma mass spectrometry [9,10], inductively coupled plasma atomic emission spectrometry [11], and electrochemical sensor TMFE [11] are also frequently employed. Procedures involving separation and preconcentration for the determination of cadmium using spectrometric techniques are reviewed by Ferreira et al. [12]. The aim of the presented work is to estimate the quantity of Cd, Pb, and As intake in sesame, especially those sold and consumed in the Khorasan province of Iran.

Methods

Apparatus

An Analytik Jena AG AAS ZEE nit 700 AAS (Jena, Germany) equipped with a hydride generation system (HS60) and graphite furnace (GF) with the Zeeman background corrector was used in the experiments. WinAAS

* Correspondence: feizyj@gmail.com

Testa Quality Control Laboratory, North-East Food Industrial Technology and Biotechnology Park, Mashhad 9176874185, Iran

Table 1 Parameters for working elements

Analyte	Wavelength (nm)	Lamp intensity (mA)	Split (nm)
Cd	228.8	3	1.2
Pb	283.3	4	0.8

software was used for data management. Cd and Pb were determined with a graphite furnace atomic absorption spectrophotometer (GFAAS). Arsenic was determined using a hydride generation atomic absorption spectrophotometer (HGAAS). The operating parameters for the working elements are given in Tables 1 and 2.

Reagents and solutions

All the analytical grade reagents were obtained from Merck (Darmstadt, Germany). Deionized double-distilled water was used throughout the experimental work. Laboratory glassware were kept overnight in 10% (v/v) nitric acid. Before use, the glassware were rinsed with deionized water and dried in a dust-free environment. The phosphate-matrix modifier solution (Merck) was added to the samples, and standards were prepared by diluting 1 mL of phosphate modifier stock solution ($\text{NH}_4\text{H}_2\text{PO}_4$ 100 $\pm$ 2 g L⁻¹ in H₂O) to 10 mL, resulting in a final concentration of 2,500 mg L⁻¹ phosphate. The sesame samples investigated in this study were locally available brands, collected in supermarkets from Khorasan province, Iran. Samples were dried; then, dried samples were homogenized using an agate homogenizer and stored in polyethylene bottles until analysis.

Results and discussion

In this work, Cd and Pb were analyzed by GFAAS and As with HGAAS. Various sources contribute to the metal composition of sesame. The main sources of heavy metals to plants are their growth media, like nutrient solution and soils [13,14]. The analytical characteristics of the atomic absorption spectrometry (AAS) method are shown in Table 3.

Accuracy was examined using the determination of the recoveries of Cd, Pb, and As. The recovery study was performed by comparing the concentration in the sesame-spiked samples to the respective non-extract standards (Cd, Pb, and As in solution). The recoveries of

Table 2 Analytical parameters for arsenic determination by HGAAS

Parameter	Result
Wavelength	193.7 nm
Acid volume	10 mL (3 mol l ⁻¹ HCl)
Reductant	10 g L ⁻¹ NaBH ₄
Reaction time	20 s
Read time	50 s

Table 3 Analytical characteristics of the AAS method

Analyte	Limit of detection (ng/mL)	Limit of quantification (ng/mL)	Repeatability (%RSD, n = 7)	Recovery ($\pm$ SD, n = 7)
Cd	0.34	1.1	1.10	98.2 ($\pm$ 2.3)
Pb	0.66	2.1	0.42	97.6 ($\pm$ 1.6)
As	0.23	0.7	3.63	98.4 ($\pm$ 2.5)

Cd, Pb, and As from samples spiked at 10 and 50 ng g⁻¹ for Cd and Pb, respectively, and 2 ng g⁻¹ for As were quite good (Table 3). Relative standard deviations for within-laboratory repeatability (RSD_r, n = 7) range from 1.6 to 2.6. The recoveries of the mineral elements were in the order of 97.6% to 98.4%. These results confirm the validity of the method for the determination of the investigated metals.

The relative standard deviations were 13.12%, 31.90%, and 26.21% for Cd, Pb, and As, respectively (Table 4). Cd, Pb, and As concentrations were compared with upper limits (100 ng g⁻¹ for Cd, Pb, and As) that was approved by the Iranian National Standard [15]. The results showed that As was the most abundant of the trace elements in sesame with an average concentration of 54 ng g⁻¹, and three (3.75%) samples were above the maximum tolerated level of Pb in Iran (100 ng g⁻¹) regulations.

Experimental

Digestion procedures

For digestion with wet ashing, 5 g of sesame samples was used (the particle sizes after grinding were below 0.3 mm). Wet digestion of the samples was performed by using mixtures of two acids, namely, HNO₃-HCl. Thirty milliliters of concentrated HNO₃ was used for a 5.0-g sample. For this procedure, the temperature was maintained at 120°C during digestion of the sample with acid mixtures on the hot plate. The sample was gently boiled until 3 to 6 mL of digest remains. Then, 25 mL of concentrated HCl was added. The heat was increased and the sample boiled until 10 to 15 mL of volume remains. After cooling, the residue was filtered through blue band filter paper. Then, the sample was diluted to 50 mL with distilled water. The blank digestions were also carried out in the same way [16].

Table 4 Metal concentration (ng/g, dry weight) of sesame samples

Analyte	Average ($\pm$ SD ^a)	Range
Cd	15.7 ($\pm$ 13.12)	0.45 to 62
Pb	51.6 ($\pm$ 31.9)	6 to 123
As	54 ($\pm$ 26.21)	13 to 99

^aSD, standard deviation.

Calibration curves

Three external standard curves were constructed using reference standard to determine the metal (Cd, Pb, and As) content in all samples. Calibration curves were determined using five or six different concentrations. The squares of correlation coefficients (r^2) were 0.989, 0.996, and 0.996 for Cd, Pb, and As, respectively.

Conclusions

In this study, 80 sesame samples from the Khorasan province of Iran were analyzed for three elements using furnace (Cd and Pb) and hydride generation (As) atomic absorption spectrophotometry and an acid digestion method. The acid digestion system in the sesame samples provides a simple and effective method of the sample digestion. This study is expected to provide an important insight into the disparity of the mineral element concentrations in different sesame samples. It is shown that Cd was detected in 76.25% with a mean value of 15.7 ng g^{-1} . Pb and As were detected in all samples with a mean value of 51.6 and 54 ng g^{-1} , respectively. Maximum contents of Cd, Pb, and As in the all samples were found as 62, 123, and 99 ng g^{-1} , respectively. Therefore, there is a need to routinely monitor these as a food quality control measure. Additional investigations, currently ongoing with our samples, will provide further information on this potentially useful taxonomic tool.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

JF conducted all the experiments mentioned in the manuscript. NKF and HRB participated in the design of the study and in drafting the manuscript and performed the statistical analysis. SSFJ participated in its design and coordination. All authors read and approved the final manuscript.

Acknowledgment

The authors thank the Testa Quality Control Laboratory (TQCL) for financial supports.

Received: 16 September 2012 Accepted: 27 December 2012

Published: 11 February 2013

References

1. Abou-Gharbia HA, Shehata AAY, Shahidi F (2000) Effect of processing on oxidative stability and lipid classes of sesame oil. *Food Res Int* 33:331–340
2. Viñas P, Pardo-Martinez M, Hernandez-Cordoba M (2000) Rapid determination of selenium, lead and cadmium in baby food samples using electrothermal atomic absorption spectrometry and slurry atomization. *Anal Chim Acta* 412:121–130
3. Kristl J, Veber M, Slekovec M (2003) The contents of Cu, Mn, Zn, Cd, Cr and Pb at different stages of the winemaking process. *Acta Chimica Slovenica* 50:123–136
4. Gama EM, da Silva LA, Lemos VA (2006) Preconcentration system for cadmium and lead determination in environmental samples using polyurethane foam/Me-BTANC. *J Hazard Mater* 136:757–762
5. Mittal SK, Goyal S (1995) Studies on suspended particulate matter in ambient air of an industrial area. *Indian J Environmental Protection* 15:839–844
6. Rudy M (2009) The analysis of correlations between the age and the level of bioaccumulation of heavy metals in tissues and the chemical

- composition of sheep meat from the region in SE Poland. *Food Chem Toxicol* 47:1117–1122
7. Sloth JJ, Julshamn K, Lundebye AK (2005) Total arsenic and inorganic arsenic content in Norwegian fish feed products. *Aquacult Nutr* 11:61–66
8. Munoz E, Palmero S (2000) Analysis and speciation of arsenic by stripping potentiometry: a review. *Talanta* 45:613–620
9. Soltys K, Fijalek Z (2000) Inductively-coupled plasma mass spectrometric (ICP-MS) and graphite-furnace atomic absorption spectrometric (GF-AAS) determinations of arsenic, cadmium and lead impurities in medical herbal raw materials. *Anal Chem* 45:879–886
10. Łozak A, Soltys K, Ostapczuk P, Fijalek Z (2002) Determination of selected trace elements in herbs and their infusions. *Sci Total Environ* 289:33–40
11. Palchetti I, Mascini M, Minunni M, Bilia AR, Vincieri FF (2003) Disposable electrochemical sensor for rapid determination heavy metals in herbal drugs. *PH Bio Anal* 32:251–256
12. Ferreira S, de Andrade Jailson B, Korn Maria das Garcas A, Pereira M, Lemos V, dos Santos W, Rodrigues F, Souza A, Ferreira H, da Silva E (2007) Review of procedures involving separation and preconcentration for the determination of cadmium using spectrometric techniques. *J Hazard Mater* 145:358–367
13. Tüzen M (2003) Determination of heavy metals in soil, mushroom and plant samples by atomic absorption spectrometry. *Microchem J* 74(3):289–297
14. Tüzen M (2003) Determination of heavy metals in fish samples of the middle Black Sea (Turkey) by graphite furnace atomic absorption spectrometry. *Food Chem* 80:119–123
15. Institute of Standards and Industrial Research of Iran (2008) Sesame seeds specification and test methods. 2nd revision, No. 323. ISIRI, Tehran
16. Association of Analytical Chemists (2005) Tin in canned foods atomic absorption spectrophotometric method. AOAC Official Method 985.16. AOAC International, Gaithersburg

doi:10.1186/2228-5547-4-10

Cite this article as: Fahim et al.: Survey of cadmium, lead, and arsenic in sesame from Iran. *International Journal of Industrial Chemistry* 2013 **4**:10.

Submit your manuscript to a SpringerOpen[®] journal and benefit from:

- Convenient online submission
- Rigorous peer review
- Immediate publication on acceptance
- Open access: articles freely available online
- High visibility within the field
- Retaining the copyright to your article

Submit your next manuscript at ► springeropen.com