Journal of Hazardous Materials 167 (2009) 647–652

Contents lists available at ScienceDirect

Journal of Hazardous Materials

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

Evaluation of trace element contents of dried apricot samples from Turkey

Sibel Saracoglu[a,*], Mustafa Tuzen[b], Mustafa Soylak[c]

[a] Erciyes University, Faculty of Education, 38039 Kayseri, Turkey
[b] Gaziosmanpasa University, Faculty of Science and Arts, Chemistry Department, 60250 Tokat, Turkey
[c] Erciyes University, Faculty of Art and Science, Department of Chemistry, 38039-Kayseri, Turkey

ARTICLE INFO

Article history:
Received 7 November 2008
Received in revised form 30 December 2008
Accepted 6 January 2009
Available online 16 January 2009

Keywords:
Trace element
Apricot
Microwave digestion
Atomic absorption spectrometry
Turkey

ABSTRACT

The trace and toxic elements (TEs) were determined in apricot samples by flame and graphite furnace atomic absorption spectrometry, prior to microwave-assisted acid digestion. Among all determined TEs, iron was found to be the dominant elemental ion as compared with other TEs in apricots followed by zinc and manganese ions. The concentration of essential TEs were observed in the range of 10.4–80.1, 0.92–6.49, 0.97–8.27, 2.96–12.0 $\mu g\,g^{-1}$, 4.76–28.9 $\mu g\,kg^{-1}$ and 0.32–0.64 $\mu g\,g^{-1}$ for iron, copper, manganese, zinc, chromium and selenium ions, respectively. While the toxic elemental contents were observed in the range of 0.02–0.72, 0.72–3.77, 2.30–5.83 and 0.08–0.22 $\mu g\,g^{-1}$ for cadmium, lead, nickel and aluminium ions, respectively. The results were compared with the literature reported values.

1. Introduction

About 30 elements are recognized as essential to life. Some are required in macronutrient amounts in essentially all forms of life: H, Na, K, Mg, Ca, C, N, O, P, S and Cl. The others occur in trace or ultratrace quantities. Fe, Cu, and Zn are at the top end of this "trace" scale. The other elements required are Li, B, F, Si, V, Cr, Mn, Co, Ni, As, Se, Mo, W, and I. The trace and ultratrace elements most important for human cellular functions are Fe, Cu, Zn, Mn, Co, Cr, V and Se. There are about 4–6 g of iron ion, 2–3 g of zinc ion, and only 250 mg of copper ion in human body. Cobalt is an essential trace element (TE) required for normal metabolism of Vitamin B12. There is one cobalt atom in this vitamin; the latter is present in only 2–5 mg quantity in the human body [1].

Elements such as iron, copper, zinc and manganese are essential elements since they play an important role in biological systems, whereas lead and cadmium are non-essential elements as they are toxic, even in traces [2]. The essential elements can also produce toxic effects when the element intake is excessively elevated. In recent years it has become clear that transition metal such as Cu, Zn, Mn, Cr, Co and Se are essential for normal development and function of human cells.

It has long been known that fruits constitute a rich source of vitamins and minerals [3]. The major part of the edible portion of fresh fruits contains 75–95% water. Fruits principally contain citric, tartaric and malic acids, with pH varying between 2.5 and 4.5. Other constituents of fruits include cellulose and woody fibers, mineral salts, pectin, gums, tannins, coloring matters and volatile oils [4]. However, in the advent of recent heavy metal contamination of the environment, the analysis of TE in seasonal fruit samples has gained considerable importance due to health considerations. As with many other fruits, numerous investigations on apricot because of the nutritional importance of this fruit have been carried out on focusing mainly on their acids, amino acid, minerals including metals and vitamin contents [3–9].

Kayseri is located in the middle Anatolia Region of Turkey (38.42°N, 35.28°E). Kayseri is an industrial agricultural city in the central Anatolia—Turkey and has a population of one million. The climate in Kayseri is dry with hot summers and cold winters. Temperature ranges between 20 and 40 °C, average values being 30 °C during summer and −5 °C during winter. Various samples (honey, mushroom and spices) have been analyzed with respect to TEs in this region [10–12].

There has been no report, to our knowledge, on the TE levels in apricot samples cultivated in Kayseri. It was therefore necessary to assess the approximate levels of TEs in local fruits grown during summer and consumed in large bulk. This study is important, especially in the advent of the fast industrialization and urbanization whereby serious threats of environmental pollution are on their way, making it still more binding to evolve an abatement program for toxic TEs in edible fruits.

* Corresponding author. Tel.: +90 352 4378834; fax: +90 352 4378834.
E-mail addresses: saracs@erciyes.edu.tr, ssarac@hotmail.com (S. Saracoglu).

0304-3894/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.jhazmat.2009.01.011

2. Experimental

2.1. Samples

In this study, 10 samples of apricots were analyzed for their TE content. Apricot samples were harvested from gardens in Kayseri, Turkey, during July 2006. The samples were placed in glass containers and transported to the laboratory. The pits of apricots were separated, and apricots were dried at room temperature for 3 days. The dried samples were homogenized using an agate homogenizer and stored in polyethylene bottles until analysis. The areas of the study were selected from different potential pollution sources and unpolluted areas.

2.2. Reagents

Analytical reagent-grade chemicals were employed in the preparation of all solutions. Doubly distilled deionised water (Milli-Q Millipore 18.2 $M\Omega\,cm^{-1}$) was used in all experiments. The HCl, HNO_3 and H_2O_2 were of suprapure quality (Merck, Darmstadt, Germany). All the plastic and glassware were cleaned by soaking in dilute nitric acid (1 + 9) and were rinsed with distilled water prior to use. The standard solutions of investigated analytes for calibration procedure were produced by diluting a stock solution of 1000 mg L^{-1} of the investigated element supplied by Sigma. 10 μL 0.015 mg Pd and 0.010 mg $Mg(NO_3)_2$ as matrix modifier was added to 20 μL sample in the determination of selenium ion. 20 μL sample and 5 μL $Mg(NO_3)_2$ were used in the determination of aluminium ion.

2.3. Apparatus

A Perkin Elmer Analyst 700 model (Norwalk, CT, USA) atomic absorption spectrometer (AAS) equipped with a deuterium background corrector was used for the determination of TEs. Measurements of Fe, Cu, Mn, Zn and Ni ions were carried out in an air/acetylene flame. The determination of Se, Cd, Pb, Cr and Al ions were performed with graphite furnace atomic absorption spectrometer (GFAAS). Argon as inert gas was used in studies with graphite furnace. Certified reference materials (CRM) were digested in a Milestone Ethos D model closed system microwave oven (maximum temperature 300 °C, maximum pressure 1×10^7 Pa). Teflon reaction vessels were used in all digestion procedures. The reaction vessels were cleaned by using 5 mL of concentrated nitric acid before each digestion.

2.4. Digestion procedures

2.4.1. Conventional wet acid digestion (CWD)

An acid digestion method induced by electric hot plate was used in order to discover the total content of TEs and also for comparative purposes. About 0.2 g of triplicate samples of certified sample while 1.0 g of apricot samples, in 50 mL Pyrex flasks and added 5–16 mL of a freshly prepared mixture of concentrated HNO_3–H_2O_2 (6:2, v/v) and stood for 10 min, then the flasks were covered with watch glass and digested at 60–70 °C for 4 h, till the clear transparent digests were obtained. The final solutions were collected in polyethylene flask, for the determinations of TEs understudy by AAS.

A blank extraction (without sample) was carried out through the complete procedures. The concentrations were obtained directly from calibration graphs after correction of the absorbance for the signal from an appropriate reagent blank.

The resulting solutions obtained from both methods were analyzed by FAAS and GFAAS by delivering 10 μL aliquots and 10 μL appropriate modifiers to the atomizer. The concentrations were

Table 1
The compare performance of CWD and microwave digestion procedure used for the digestion of an apricot sample (numbered 1), $N = 3$.

Method	Concentrations ($\mu g\,g^{-1}$)										
	Cu	Mn	Fe	Zn	Se	Cd	Pb	Ni	Cr[a]	Al
Microwave digestion	2.42 ± 0.16	7.53 ± 0.38	80.1 ± 3.5	12.0 ± 1.1	0.47 ± 0.02	0.22 ± 0.02	2.50 ± 0.17	3.66 ± 0.14	16.9 ± 1.1	0.10 ± 0.01
CWD	2.25 ± 0.20	7.10 ± 0.65	76.8 ± 6.8	11.7 ± 1.1	0.32 ± 0.03	0.19 ± 0.02	2.36 ± 0.22	3.41 ± 0.30	16.2 ± 1.4	0.09 ± 0.01

[a] Cr ($\mu g\,kg^{-1}$).

obtained directly from calibration graphs after correction of the absorbance for the signal from an appropriate reagent blank.

2.4.2. Microwave digestion

A microwave-assisted digestion procedure was carried out, in order to achieve a shorter digestion time. Weighed triplicate 0.2 g of certified samples and 1.0 g of real samples in reaction vessels (100 mL in capacity) directly, added to each flasks 8 mL of a freshly prepared mixture of concentrated HNO_3–H_2O_2 (6:2, v/v) and stood for 10 min. Digestion conditions for the microwave system were applied as 2 min for 250 W, 2 min for 0 W, 6 min for 250 W, 5 min for 400 W, 8 min for 550 W, vent: 8 min. After cooling, the resulting solutions were diluted up to 10.0 mL in volumetric flasks with 1 M HNO_3. Blank digest was carried out in the same way.

3. Results and discussion

The certain TEs are very important for human biology [13–15]. Food and water are the main sources of essential elements; these are also the media through which we are exposed to various toxic elements. A number of serious health problems can develop as a result of excessive uptake of dietary TEs. Furthermore, the consumption of contaminated food can seriously deplete some essential nutrients in the body causing a decrease in immunological defenses, intrauterine growth retardation, impaired psycho-social behavior, disabilities associated with malnutrition and a high prevalence of upper gastrointestinal cancer [16]. From the above knowledge it is clear that analysis of TEs in food is important for human health.

Both the detection limit (based on three times the standard deviations of the reagent blank) and the characteristic masses (based on 0.0044 absorbance) were calculated for the investigated analyte ions. The detection limit values of the investigated elements for flame AAS were found to be 0.013, 0.019, 0.011, 0.010 and 0.025 mg L^{-1} for Cu (II), Zn (II), Fe (III), Mn (II) and Ni (II) ions, respectively. The characteristic mass values were Al: 17 pg, Cd: 10 pg, Pb: 21 pg, Cr: 15 pg and Se: 22 pg in graphite furnace AAS. In the precision test, the average R.S.D.% for all analytes was in the range of 1–10%.

Performance of digestion procedures using CWD and microwave digestion prior to the determination with AAS of some TEs in apricot samples was compared in presented work. The results are given in Table 1. The slightly high TE levels were obtained when the microwave oven was used. The approximate time required for wet and microwave digestions were 4 h and 31 min, respectively.

For the validation of both analysis and digestion, a CRM of apple leaves (NIST SRM 1515) was used. The CRM was employed to check the correctness of digestion methods. The certified and observed values for the CRM were given in Table 2. As can be seen that quantitative recoveries of Cu (II), Mn (II), Fe (III), Zn (II), Pb (II), Ni(II), Cr (III) and Al (III) were obtained by both digestion methods. When the microwave digestion method was used, recovery value for Se ion was quantitative, while for CWD method, 70% and 85% of the recoveries for Se and Cd, respectively, were obtained. The underlying reason for getting these results might be that these elements are volatile. The low recovery for volatile elements in the digestion by the CWD method arising the heating vessel in the open air for long time (4 h). Therefore, this method is not proper for the digestion of samples to measure of Se, Hg, Cd. Whereas the recoveries of these elements were quantitative when microwave digestion procedure was used.

In light of these results, the microwave digestion procedure was chosen for the digestion of all the apricot samples, because of shorter required time and higher recovery and easier than CWD. If the analyzed concentration levels of the most common matrix constituents of CRM and the accuracy of the presented methods are considered together, it can be concluded that the proposed method is free from interferences of various constituents.

The concentrations of investigated elements in apricot samples were determined on a dry weight basis and given in Table 3.

The concentrations of essential TEs were observed in the range of 10.4–80.1, 0.92–6.49, 0.97–8.27, 2.96–12.0 $\mu g\,g^{-1}$, 4.76–28.9 $\mu g\,kg^{-1}$ and 0.32–0.64 $\mu g\,g^{-1}$ for iron, copper, manganese, zinc, chromium and selenium ions, respectively. While the toxic elemental contents were observed in the range of 0.02–0.72, 0.72–3.77, 2.30–5.83 and 0.08–0.22 $\mu g\,g^{-1}$ for cadmium, lead, nickel and aluminium ions, respectively. Among all determined TEs iron was found to be the dominant elemental ion as compared with other TEs in apricots followed by zinc and manganese ions. It is known that adequate iron in a diet is very important for decreasing the incidence of anemia. Iron deficiency occurs when the demand for iron is high, e.g., in growth, high menstrual loss, and pregnancy, and the intake is quantitatively inadequate or contains elements that render the iron unavailable for absorption [17]. Zinc is an essential metal for the normal function of various enzyme systems. Zinc deficiency which can be comprehensible with the stain of fingernail occurs when the intake of zinc with meat and its products is quantitatively inadequate. The deficiency of zinc particularly in children can lead to loss of appetite, growth retardation, weakness, low spirited, stagnation in sexual growth.

The FAO/WHO has set a limit for TEs intakes based on body weight. For an average adult (60 kg body weight), the provisional tolerable daily intake (PTDI) for iron, copper and zinc are 48, 3 and 60 mg, respectively [18].

Copper is the third most abundant TE in human body, with vitamin-like impact on living systems. Small amount of copper is found in the human body (50–120 mg), but it plays a critical role in a variety of biochemical processes. Copper is known to be vital for many biological systems. Copper forms part of at least 13 different enzymes, and its presence is needed for each if they are to function properly. These enzymes such as cytochrome oxidase, tyrosinase, cytocsidase, monoamine oxidase promote energy production, prevent anemia and bone disease, battle cell damage and assist in fetal and infant development [19]. In addition, copper is necessary for proper metabolism of iron, maintenance of connective tissue, pigmentation of skin and hair, maturation of hoof tissue, and many other functions [20]. The lowest and highest contents of copper ion in apricot samples were found as 0.92 $\mu g\,g^{-1}$ and 6.49 $\mu g\,g^{-1}$, respectively. The average concentration of copper ion in our apricot samples is higher than apricot of USA (0.1851 $\mu g\,mL^{-1}$) [21].

Manganese is one of the vital important elements. Manganese is both to be in structure of some enzymes and active to some enzymes. The mean of manganese ion contents in apricot samples was 4.68 $\mu g\,g^{-1}$. Barnes reported that the average concentration of Mn in apricot of USA, 0.273 $\mu g\,mL^{-1}$ [21]. The levels of Mn (II) ion in our samples are higher than in apricots of USA. The Institute of Medicine recommends that intake of manganese from food; water and dietary supplements should not exceed the tolerable daily upper limit of 11 mg per day [22]. The intake of Mn in our investigated samples is below the tolerable daily upper limit of 11 mg per day. The US National Academy of Sciences recommended 2.5–5 mg per day manganese [23] and, the WHO (World Health Organization) recommended 2–9 mg per day for an adult [24].

The lowest and highest levels of iron ion in apricot samples were found as 10.4 and 80.1 $\mu g\,g^{-1}$, respectively. Apricot was also good sources of Fe. Zahoor et al. reported that Fe concentrations in apricot sold in supermarket of Pakistan were 11.9 mg kg^{-1} [4]. The concentrations of Fe ion in different spices, dry fruits and plant nuts commonly consumed in Pakistan were found in the range of 142–285 $\mu g\,g^{-1}$ [25]. Ghaedi et al. reported that the level of Fe (III) ion was found as 0.568 $\mu g\,g^{-1}$ in orange juice of Iran [26]. The level

Table 2
Analysis with wet and microwave digestion methods of NIST SRM 1515 apple leaves ($\mu g\,g^{-1}$), $N = 3$.

Element	Certified value	CWD	Recovery (%)	Microwave digestion	Recovery (%)
Cu	5.64	5.25 ± 0.50	93	5.40 ± 0.25	96
Mn	54	51.3 ± 4.3	95	53.6 ± 2.7	99
Fe	(83)[a]	78.9 ± 5.6	95	81.5 ± 4.2	98
Zn	12.5	11.9 ± 1.1	95	12.3 ± 0.8	98
Se	0.05	0.035 ± 0.003	70	0.048 ± 0.002	96
Cd	0.013	0.011 ± 0.001	85	0.012 ± 0.001	92
Pb	0.47	0.45 ± 0.04	96	0.46 ± 0.03	98
Ni	0.91	0.86 ± 0.07	95	0.89 ± 0.05	98
Cr	(0.3)[a]	0.29 ± 0.02	97	0.30 ± 0.02	100
Al	286	272 ± 15.4	95	283 ± 11.6	99

[a] Value in bracket is not certified value.

of iron ion in apricot samples from Turkey is higher than Fe contents in apricot of Pakistan and in orange juice of Iran. The maximum iron ion level permitted for food is 15 mg kg^{-1} according to Turkish Food Codex [27]. Iron ion levels in the most of analyzed apricot samples were found to be higher than legal limits.

Zinc is an essential TE for human health; it has been recognized as a co-factor of the superoxide dismutase enzyme, which is involved in protection against oxidative processes [28]. The concentration of Zn (II) ion in apricot was found in the range of 2.96–12.0 $\mu g\,g^{-1}$. The study thus showed that apricot was rich source of Zn ion, an element which supports many enzymatic reactions in the human body. The Zn (II) concentration in our apricot sample is higher than in the apricots of Pakistan by Zahoor et al. [4]. Sattar et al. reported that the lowest and highest levels of Zn (II) ion were found as 64.2 and 65.8 $\mu g\,g^{-1}$ in spices, dry fruit and plant nuts from Pakistan, respectively [25]. Alam et al. reported that the average weekly intake of Zn (II) ion from Samta vegetables is estimated to be 25 mg [28]. The concentration of Zn ion was reported as 0.33 $\mu g\,mL^{-1}$ in apricot juice in USA by Barnes [21]. The maximum level of zinc ion permitted for food is 5 mg kg^{-1} according to Turkish Food Codex [27]. The levels of zinc ion in analyzed apricot samples were found to be higher than legal limits. The maximum tolerable daily intake of Zn is 0.3–1 mg kg^{-1} [29]. Our values for Zn (II) ion in understudy apricot samples were above the WHO's values.

Selenium is recognized as an essential micronutrient in animal and humans. Selenium, functioning as part of glutathione peroxidase, has been recognized as a cellular antioxidant in addition to its protecting function against heavy metal toxicity [30]. Moreover, it plays important biological roles as antioxidant, as a regulator of thyroid hormone metabolism and as hear functional regulator, as well as rheumatism illness preventive [31,32]. Low concentrations of selenium can cause anomalies in organisms while high concentrations are toxic. It has been pointed out that the selenium ion concentrations in the range 2–8 mg g^{-1} in foods are harmful [33]. The highest selenium ion content was 0.64 $\mu g\,g^{-1}$, whereas the lowest selenium ion contents were 0.32 $\mu g\,g^{-1}$. The concentration of Se ion was reported as 0.219 $\mu g\,mL^{-1}$ in apricot juice from USA by Barnes [21]. The Se content of dried apricot is higher than fresh apricot in USA. Munzuroglu et al. reported that levels of selenium ion were 3–4-fold higher in dried fruit than in fresh fruit [3]. The adequate daily dietary selenium intake ranges from 50 to 200 μg, with an average value of 55 μg for adult humans [34]. Daily intake of selenium in Turkey has been reported as 30 μg/day [35]. Bioavailability of selenium in food samples is affected by its chemical form and also by other dietary factors such as total protein, fat and heavy metal contents.

Cadmium is a highly toxic metal with a natural occurrence in soil, but it is also spread in the environment due to human activities. It is easily taken up and accumulated by plants and crops through the root systems [28]. The concentration of cadmium ion was observed in the range of 0.02–0.72 $\mu g\,g^{-1}$ with mean value 0.17 $\mu g\,g^{-1}$ in investigated apricot samples. The concentration of Cd (II) ion was found in the range of 0.09–0.21 mg kg^{-1} in apricot of Pakistan by Zahoor et al. [4]. The results in present study agree with study in Pakistan.

Lead is like to be Cd that has no beneficial role in human metabolism, producing progressive toxicity. Exposure to lead is of concern mainly because of its possible detrimental effects on intelligence [28].

Lead can reach humans through air, water and food. Lead is accumulating in bones and it can take in place of calcium. Lead creates health disorders such as sleeplessness, tiredness, hear and weight loss. WHO has established a provisional tolerable weekly intake for lead of 0.025 mg kg^{-1} of body weight [36]. The lead ion content in apricot samples investigated was 1.91 $\mu g\,g^{-1}$ as average value. The level of Pb (II) ion was reported as 1.66 mg kg^{-1} in apricot of Pakistan by Zahoor et al. [4]. Sattar et al. reported that the concentration of Pb ion in spices, dry fruit and plant nuts from Pakistan was in the range of 6.6–9.2 $\mu g\,g^{-1}$ [25]. The level of Pb (II) ion in our samples is lower than Pb levels in foodstuffs of Pakistan.

Furthermore, the minimum and maximum concentrations of nickel ion were 2.30 $\mu g\,g^{-1}$ and 5.83 $\mu g\,g^{-1}$, respectively. Zahoor et

Table 3
Trace element contents of apricot samples, $N = 3$.

Sample number	Concentrations ($\mu g\,g^{-1}$)									
	Cu	Mn	Fe	Zn	Se	Cd	Pb	Ni	Cr[a]	Al
1	2.42 ± 0.16	7.53 ± 0.38	80.1 ± 3.5	12.0 ± 1.1	0.47 ± 0.02	0.22 ± 0.02	2.50 ± 0.17	3.66 ± 0.14	16.9 ± 1.1	0.10 ± 0.01
2	1.94 ± 0.18	4.82 ± 0.27	51.7 ± 2.6	10.5 ± 0.9	0.34 ± 0.03	0.15 ± 0.01	2.51 ± 0.23	4.05 ± 0.25	12.9 ± 0.9	0.13 ± 0.01
3	0.92 ± 0.07	7.40 ± 0.66	73.8 ± 5.5	5.71 ± 0.42	0.41 ± 0.04	0.13 ± 0.01	2.46 ± 0.15	4.33 ± 0.18	28.9 ± 1.5	0.11 ± 0.01
4	1.13 ± 0.10	4.59 ± 0.30	69.1 ± 3.7	9.59 ± 0.70	0.64 ± 0.05	0.05 ± 0.01	0.77 ± 0.05	3.51 ± 0.26	15.1 ± 1.2	0.15 ± 0.01
5	6.49 ± 0.45	3.75 ± 0.32	64.7 ± 4.9	5.61 ± 0.42	0.32 ± 0.03	0.06 ± 0.01	0.76 ± 0.06	4.13 ± 0.35	10.6 ± 0.8	0.22 ± 0.02
6	4.19 ± 0.32	3.73 ± 0.35	63.2 ± 5.1	6.09 ± 0.35	0.33 ± 0.02	0.08 ± 0.01	3.77 ± 0.18	2.30 ± 0.10	4.95 ± 0.30	0.20 ± 0.02
7	1.82 ± 0.14	4.21 ± 0.29	33.9 ± 2.3	6.38 ± 0.50	0.32 ± 0.03	0.72 ± 0.01	2.35 ± 0.14	3.10 ± 0.25	6.69 ± 0.50	0.12 ± 0.01
8	4.15 ± 0.35	1.57 ± 0.10	36.3 ± 2.9	9.29 ± 0.61	0.43 ± 0.04	0.02 ± 0.01	2.49 ± 0.18	4.38 ± 0.40	5.32 ± 0.35	0.14 ± 0.01
9	4.63 ± 0.40	8.27 ± 0.51	35.1 ± 3.2	5.13 ± 0.32	0.35 ± 0.02	0.05 ± 0.01	0.80 ± 0.06	5.83 ± 0.37	5.78 ± 0.40	0.10 ± 0.01
10	3.17 ± 0.28	0.97 ± 0.08	10.4 ± 0.9	2.96 ± 0.16	0.39 ± 0.03	0.25 ± 0.02	0.72 ± 0.05	2.93 ± 0.22	4.76 ± 0.32	0.08 ± 0.01

[a] Cr ($\mu g\,kg^{-1}$).

al. reported that the levels of Ni (II) ion were found as 7.50 mg kg^{-1} in apricots of Pakistan [4]. The average concentration of nickel ion in the present study (3.82 μg g^{-1}) is lower than those value reported in apricot of Pakistan. Trace amounts of nickel may be beneficial as an activator of some enzyme systems, but its toxicity at higher levels is more prominent. It accumulates in the lungs and may cause bronchial haemorrhage or collapse [37]. The WHO recommends 100–300 μg g^{-1} nickel for daily intake [24]. However, the amount of nickel ingested daily can reach 900 μg after consumption of foods rich in nickel [38].

Chromium is an essential TE that plays essential role in our life and health [39]. Chromium is important for glucose tolerance in human body. It works with insulin to facilitate the uptake of glucose into cells. In individuals with impaired glucose tolerance, such as those with diabetes, hypoglycemia, and obesity, supplementation with chromium is of paramount importance. Without chromium, blood sugar levels stay elevated because the action of insulin is blocked so that glucose is not transported into the cells for energy production [40]. Data from US Government sources show that the great majority of Americans get less chromium in their daily diets than the amount recommended by nutrition experts (the RDA Committee recommends 50–200 μg of chromium/day) [22]. The average concentration of chromium ion of apricot was 11.2 μg kg^{-1}. The similar result was obtained from apricot samples of USA (0.0134 μg mL^{-1}) [21]. Reported Cr values for apricot samples in the literature (6.43 and 3.23 mg kg^{-1}) [4] are higher than those found in the present study. The estimated requirement for chromium ion in humans is about 1 μg/(kg day), but only 1–3% of trivalent chromium ion is absorbed. In the USA, chromium intakes range from 20 to 50 μg/day, with plasma levels from 0.05 to 0.50 μg L^{-1}. The Food and Nutrition Board of the NAS/NRC states that a safe, adequate intake of chromium for an adult is 50–200 μg/day [41].

Aluminium ion contents of apricot samples were found in the range of 0.08–0.22 μg g^{-1}. Aluminium is not considered to be an essential element in humans. Exposure of aluminium has been implicated in a number of human pathologies including encephalopathy/dialysis dementia, Parkinson disease and Alzheimer's disease [42,43]. The permissible aluminium dose for an adult is quite high (60 mg per day) [44]. The main sources of aluminium ion for the human organism are foods and drinking water. Aluminium ion is present in food naturally, from its addition as food additives, and through contact with Al used in food preparation and storage [45].

According to the results (Table 3), the TE contents in the samples studied depend on the pollution of growing environment of analyzed species. TE content of apricot in sample 1 was found as generally higher than other area, because of traffic density at this place.

4. Conclusions

The analysis of TEs contents of plant samples from environment is an important analytical chemistry [46–48]. Local, seasonal fruits are in general a good dietary resource, especially in macro- and micro-nutrients. The sources of these elements in the local fruits could be traced back to soil, fertilizer, water, or environmental metal pollution. The present study also showed that the apricot is a rich resource of Fe and Zn. Hence this fruit may be used as supplement in deficiency symptoms in patients suffering from ailment directly or indirectly related to the disturbed metabolism involving these two metals. The local fruits pose a threat to local consumers in terms of toxic elements, especially Pb. The study showed that levels of Cd (II) ion in apricots are well below the safe limit laid down by the WHO, whereas the Pb (II) and Ni (II) ions levels in apricots are above the safe limit, according to permissible limit of WHO. Disparate viewpoints regarding the significance of heavy metal contamination have resulted in varying regulatory approaches towards safeguarding human and environment health.

Acknowledgements

The authors are grateful for the financial support of the Unit of the Scientific Research Projects of Gaziosmanpasa University and the Unit of the Scientific Research Projects of Erciyes University.

References

[1] F.A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 5th ed., Wiley-Interscience, New York, 1988, p. 1455.
[2] H.A. Schroeder, The Trace Elements and Nutrition, Faber and Faber, London, 1973.
[3] O. Munzuroglu, F. Karatas, H. Geckil, The vitamin and selenium contents of apricot fruit of different varieties cultivated in different geographical regions, Food Chem. 83 (2003) 205–212.
[4] A. Zahoor, M. Jaffar, M. Saqib, Elemental distribution in summer fruits of Pakistan, Nutr. Food Sci. 33 (2003) 203–207.
[5] I. Gezer, M. Acaroglu, H. Haciseferogullari, Use of energy and labour in apricot agriculture in Turkey, Biomass Bioenergy 24 (2003) 215–219.
[6] A. Versari, A. Mattioli, G.P. Parpinello, S. Galassi, Rapid analysis of ascorbic and isoascorbic acids in fruit juice by capillary electrophoresis, Food Control 15 (2004) 355–358.
[7] G.A. Evrendilek, F.M. Tok, E.M. Soylu, S. Soylu, Inactivation of *Penicillum expansum* in sour cherry juice, peach and apricot nectars by pulsed electric fields, Food Microbiol. 25 (2008) 662–667.
[8] G. Campo, I. Berregi, R. Caracena, J.I. Santos, Quantitative analysis of malic and citric acids in fruit juices using proton nuclear magnetic resonance spectroscopy, Anal. Chim. Acta 556 (2006) 462–468.
[9] Z.F. Katona, P. Sass, I. Molnar-Perl, Simultaneous determination of sugars, sugar alcohols, acids and amino acids in apricots by gas chromatography–mass spectrometry, J. Chromatogr. A 847 (1999) 91–102.
[10] M. Tuzen, M. Soylak, Trace heavy metal levels in microwave digested honey samples from middle Anatolia, Turkey, J. Food Drug Anal. 13 (2005) 343–347.
[11] M. Soylak, S. Saracoglu, M. Tuzen, D. Mendil, Determination of trace metals in mushroom samples from Kayseri, Turkey, Food Chem. 92 (2005) 649–652.
[12] M. Soylak, H. Colak, O. Turkoglu, Heavy metal content of some cereals, spices and pulses from middle Anatolia Region of Turkey, Fresen. Environ. Bull. 15 (2006) 345–348.
[13] H.I. Afridi, T.G. Kazi, M.K. Jamali, M.B. Arain, N. Jalbani, J.A. Baig, Distribution of zinc, copper and iron in biological samples of Pakistani myocardial infarction (1st, 2nd and 3rd heart attack) patients and controls, Clin. Chim. Acta 389 (1–2) (2008) 114–119.
[14] T.G. Kazi, A.R. Memon, H.I. Afridi, M.K. Jamali, M.B. Arain, N. Jalbani, R.A. Sarfrz, Determination of cadmium in whole blood and scalp hair samples of Pakistani male lung cancer patients by electro thermal atomic absorption spectrometer, Sci. Total Environ. 389 (2-3) (2008) 270–276.
[15] A.R. Memon, T.G. Kazi, M.K. Jamali, H.I. Afridi, M.B. Arain, N. Jalbani, Evaluation of zinc status in biological samples (whole blood and scalp hair) of female cancer patients, Clin. Chim. Acta 379 (2007) 66–70.
[16] M. Arora, B. Kiran, S. Rani, A. Rani, B. Kaur, N. Mittal, Heavy metal accumulation in vegetables irrigated with water from different sources, Food Chem. 111 (2008) 811–815.
[17] S.R. Lynch, R.D. Baynes, Deliberations and evaluations of the approaches, endpoints and paradigms for iron dietary recommendations, Am. Inst. Nutr. (1996) 2404–2409.
[18] Joint FAO/WHO, Expert Committee on Food Additives, Summary and Conclusions, 53rd Meeting, Rome, 1999.
[19] Copper Development Association Inc., 2008, http://www.copper.org/consumers/copperhome/Env_Health/environmentandhealth_health.html.
[20] J. Nix, 1992, http://www.sweetlix.com/user_files/File/articles/Goat_012.pdf.
[21] K.W. Barnes, Trace metal determinations in fruit, juice, and juice products using axially viewed plasma, Atom. Spectrosc. 18 (3) (1997) 84–100.
[22] F.M. Peter, Recommended Dietary Allowance (RDA), 10th ed., National Academic Pres, Washington, 1989, p. 285.
[23] National Academy of Sciences, Recommended Dietary Allowances, 9th ed., National Academic Press, Washington, 1980.
[24] World Health Organization, Quality Directive of Potable Water, 2nd ed., WHO, Geneva, 1994, p. 197.
[25] A. Sattar, M. Wahid, S.K. Durrani, Concentration of selected heavy metals in spices, dry fruits and plant nuts, Plant Food Hum. Nutr. 39 (1989) 279–286.
[26] M. Ghaedi, A. Shokrollahi, R. Mehrnoosh, O. Hossaini, M. Soylak, Combination of cloud point extraction and flame atomic absorption spectrometry for preconcentration and determination of trace iron in environmental and biological samples, Cent. Eur. J. Chem. 6 (3) (2008) 488–496.
[27] Anonymous Regulation of setting maximum levels for certain contaminants in foodstuffs, Official Gazette, Iss: 24908, 2002.
[28] M.G.M. Alam, E.T. Snow, A. Tanakab, Arsenic and heavy metal contamination of vegetables grown in Samta village, Bangladesh, Sci. Total Environ. 308 (2003) 83–96.

[29] World Health Organization, Evaluation of Certain Food Additives and Contaminants, Twenty sixth Report of the Joint FAO/WHO Expert Committee on Food Additives, World Health Organization, Geneva, WHO Technical Report Series No. 683, 1982.
[30] I.A. Al-Saleh, I. Al-Doush, Selenium levels in wheat grains grown in Saudi Arabia, Bull. Environ. Contam. Toxicol. 59 (1997) 590–594.
[31] B. Dashti, F. Al-Awadi, R. AlKandari, A. Ali, J. Al-Otaibi, Macro- and microelements contents of 32 Kuwaiti composite dishes, Food Chem. 85 (2004) 331–337.
[32] T.C. Stadtman, Selenium biochemistry, Annu. Rev. Biochem. 59 (1990) 111–127.
[33] P. Vinas, M.P. Martnez, M.H. Cordoba, Rapid determination of selenium, lead and cadmium in baby food samples using electrothermal atomic absorption spectrometry and slurry atomization, Anal. Chim. Acta 412 (2000) 121–130.
[34] Food and Nutrition Board, Institute of Medicine, Dietary Reference Intakes for Vitamin C, Vitamin E, Selenium and Carotenoids, The National Academies Press, Washington, DC, 2000.
[35] L.H. Foster, S. Sumar, Selenium in health and disease: a review, Crit. Rev. Food Sci. Nutr. 37 (1997) 211–228.
[36] World Health Organization, Guidelines for Drinking Water Quality, WHO, Geneva, 1993.
[37] E.J. Underwood, Trace Elements in Human and Animal Nutrition, 4th ed., Academic Press, New York, 1977.
[38] G.H. Biego, M. Joyeux, P. Hartemann, G. Debry, Daily intake of essential minerals and metallic micropollutants from foods in France, Sci. Total Environ. 217 (1998) 27–36.
[39] S. Mutuma, P. Amuna, H. Shukla, S. Sumar, Chromium in food, nutrition and health—an introduction, Nutr. Food Sci. 2 (1999) 81–88.
[40] T.H. Lim, T. Sargent, N. Kusubov, Kinetics of trace element chromium(III) in the human body, Am. J. Physiol. Regul. Integr. Comp. Physiol. 244 (1983) 445–454.
[41] S.K. Gupta, Bioderm Research, 2006, http://www.freepatentsonline.com/20060183708.html.
[42] I. Narin, M. Tuzen, M. Soylak, Aluminium determination in environmental samples by graphite furnace atomic absorption spectrometry after solid phase extraction on amberlite XAD-1180/pyrocatechol violet chelating resin, Talanta 63 (2004) 411–418.
[43] A. Shokrollahi, M. Ghaedi, M.S. Niband, H.R. Rajabi, Selective and sensitive spectrophotometric method for determination of sub-micro-molar amounts of aluminium ion, J. Hazard. Mater. 151 (2008) 642–648.
[44] World Health Organization, Evaluation of certain food additives and contaminants, In Thirty-third report of the Joint FAO/WHO Expert Committee on food additives, WHO technical report series, WHO, Geneva, 776 (1989) 26–27.
[45] S.M. Saiyed, R.A. Yokel, Aluminium content of some foods and food products in the USA, with aluminium food additives, Food Addit. Contam. 22 (2005) 234–244.
[46] M. Ghaedi, F. Ahmadi, A. Shokrollahi, Simultaneous preconcentration and determination of copper, nickel, cobalt and lead ions content by flame atomic absorption spectrometry, J. Hazard. Mater. 142 (2007) 272–278.
[47] U. Divrikli, N. Horzum, M. Soylak, L. Elçi, Trace Heavy Metal Contents of Some Spices and Herbal Plants from Western Anatolia—Turkey, Int. J. Food Sci. Technol. 41 (2006) 712–716.
[48] M.K. Jamali, T.G. Kazi, M.B. Arain, H.I. Afridi, N. Jalbani, G.A. Kandhro, A.Q. Shah, J.A. Baig, Heavy metal accumulation in different verities of wheat (Triticum aestivum L.) grown in soil amended with domestic sewage sludge, J. Hazard. Mater, in press.