International Journal of Horticultural Science 2010, 16 (4): 61–65.
Agroinform Publishing House, Budapest, Printed in Hungary
ISSN 1585-0404

Hazardous element content and consumption risk of 9 apricot cultivars

Davarynejad, G. H.[1*], Vatandoost, S.[1], Soltész, M.[2], Nyéki, J.[2], Szabó, Z.[2] & Nagy, P. T.[2]

[1]Department of Horticultural Science, Ferdowsi University of Mashhad, Iran. Po.box 91775-1163.
**e-mail: davarynej@um.ac.ir*
[2]Institute for Research and Development, University of Debrecen,
H-4032 Debrecen, 138 Böszörményi street, Hungary

Summary: The heavy metals pollution is one of the problems that arise due to the increased uses of fertilizers and other chemicals to meet the higher demands of food production for human consumption. In order to assess possible health risk of apricot (*Prunus armeniaca L.*) consumption, levels of Arsenic, Cadmium, Mercury and Lead were determined in fresh and dried samples of "Jumbo cot", "Tom cot", "Gold strike", "Gold bar", "Bergeron", "Bergarouge", "Sweet cot", "Yellow cot" and "Zebra" apricot cultivars. Wet digestion of samples with concentrate HNO_3 – H_2O_2 digester mixture and inductively coupled plasma–atomic emission spectroscopy was used. Highest content of As, Cd, Hg and Pb among all cultivars, were 0.5, 0.04, 1.5 and 0.5mg/kg of dried apricot samples. Fresh fruit samples also contain 0.2, 0.016, 0.6 and 0.2 mg/kg of Arsenic, Cadmium, Mercury and Lead respectively. Daily intake of metals, hazard quotient and health risk index to reveal health risk possibility of dried and fresh fruits consumption were calculate and compared.

Key words: *Prunus armeniaca* L., chemical composition, heavy metals, health risk index

Introduction

Food safety is a major public concern worldwide. During the last decades, the increasing demand of food safety has stimulated research regarding the risk associated with consumption of foodstuffs contaminated by pesticides, heavy metals or toxins (*Dmello,* 2003). According to *Zhuang* et al. (2009) Arsenic (As), Cadmium (Cd), Mercury (Hg) and Lead (Pb) may inadvertently enter the food chain and pose health risks to humans. Bordajandi et al., 2004 believe that human exposure to heavy metals can occur through a variety of routes, such as inhalation of air pollutants or contaminated soil particles and consumption of contaminated foods. Heavy metals contaminated of orange fruits by *Rossini* et al., (2003), plantain by *Selema & Farago* (1996), mango and almond by *Ademoroti* (1986), lemon, sweet orange and grapefruits by *Gorinstein* et al. (2001), chiku, papaya, mango, muskmelon and apple by *Parveen* et al. (2003), quince and grape by *Pinochet* et al. (1999), strawberry by *Ward* and *Savage* (1994), banana, pineapple and papaya by *Santos* et al. (2004) carambola, longan, wampee, mango and almond fruits by *Ademoroti* (1986) and *Li* et al. (2006), date palm by *Williams* et al. (2005) and apricot by *Saracoglu* et al. (2009) are studied. Different reasons may cause contamination of fruits and vegetables with heavy metals. Using mineral fertilisers (*Nicholson* et al. 2003), (*Eckel* et al. 2005) and *Lugon-moulin* et al. 2006), contaminated water (Arora et al. 2008), industrial emission and transportation (*Gratani* et al. 2008), mining and processing metal ore (*Sing* et al. 2005) are the main sources of heavy metals in agricultural systems. Whereas, Arsenic is a very toxic metalloid. It has a serious impact on the human health. The inorganic form of As is toxic to human being. Arsenic and trace metal can inter into the plants from soil and hence in food chain from contaminated soil and may infect human being as well. The terrestrial plants can accumulate a large amount of arsenic (inorganic form) from soils and transfer it to the aboveground biomass (*Zhang* et al. 2002).

The International Agency for Research on Cancer (IARC) places inorganic As in drinking water in the highest health hazard category, i.e.a group 1 carcinogen, and there is substantial evidence that it increases risk of cancer of the bladder, lung, skin, and prostate (USA National Research Council, 2001). Food is also a potentially important source of dietary Arsenic intake (*Schoof,* 1999). In this study arsenic level of apricot fruits is higher than his results obtaned by *Creger* (1992) which reported 70 ug/kg of arsenic concentration in fresh samples of apricot fruits.

The nervous system is very sensitive to mercury. In poisoning incidents some people who ate fish contaminated with large amounts of methylmercury or seed grains treated with methylmercury or other organic mercury compounds developed permanent damage to the brain and kidneys. Permanent damage to the brain has also been shown to occur from exposure to sufficiently high levels of metallic mercury. Whether exposure to inorganic mercury results in brain or nerve damage is not as certain, since it does not easily pass from the blood into the brain. Metallic mercury vapors or organic mercury may affect many different areas of the brain and their associated functions, resulting in a variety of symptoms. These include personality changes (irritability, shyness, and nervousness), tremors, changes in vision (constriction or narrowing) of the visual field, deafness, muscle incoordination, loss of sensation, and difficulties with memory. The kidneys are also sensitive to the effects of mercury, because mercury accumulates in the kidneys and causes higher exposures to these tissues, and thus more damage. In addition to effects on the kidneys, inorganic mercury can damage the stomach and intestines, producing symptoms of nausea, diarrhea, or severe ulcers if swallowed in large amounts. Effects on the heart have also been observed in children after they accidentally swallowed mercuric chloride

Apricots like other fruits constitute a rich source of vitamins and minerals (*Munzuroglu* et al., 2003), and they are rich in β-carotenes. About 15–20% of apricots produced are consumed fresh and the rest are processed as canned, dried, frozen, jam, juice, and puree (*Hui,* 2006). Dried apricots are a concentrated source of fiber and one of the highly nutrient-dense dried fruits (*Rieger,* 2004). *Table 1* shows chemical composition of fresh and raw, canned, frozen, Dried, nectar and Processed apricot. (*USDA,* 2009).

The purpose of the present study was determination of the concentrations of toxic elements in 9 apricot cultivars grown in Hungry and to estimate their contribution to the human daily intake of those elements by using daily intake of metals (DIM), hazard quotient (HQ)and health risk index (HRI) to reveal health risk possibility of dried and fresh fruits consumption. (*Li,* 2009)

Table 1. Composition of Apricots and their Processed Products (per 100 g edible portion)

Nutrient	Unit	Raw apricots	Canned apricots	Frozen Apricots	Dried Apricots	Apricot Nectar
Proximate						
Water	g	86.35	82.56	73.3	30.89	84.87
Energy	Kcal	48	63	98	241	56
Protein	g	1.4	0.53	0.7	3.39	0.37
Total Lipid	g	0.39	0.05	0.1	0.51	0.09
Fatty acids	g	0.027	0.003	0.007	0.017	0.006
Carbohydrate	g	11.12	16.49	25.1	62.64	14.39
Fiber (total)	g	2	1.6	2.2	7.3	0.6
Sugars (total)	g	9.24	14.89	----	53.44	13.79
Vitamines						
Vitamin A, IU	IU	1926	1322	1680	3604	1316
Vitamin C, total ascorbic acid	mg	10	2.7	9	1	0.6
Thiamin	mg	0.03	0.016	0.02	0.015	0.009
Riboflavin	mg	0.04	0.02	0.04	0.074	0.014
Niacin	mg	0.6	0.304	0.8	2.589	0.26
Pantothenic acid	mg	0.24	0.092	0.2	0.516	0.096
Vitamin B-6	mg	0.054	0.054	0.06	0.143	0.022
Folate, total	mcg	9	2	2	10	1
Vitamin E	mg	0.89	0.6	-----	4.33	0.31
Vitamin K	mcg	3.3	2.2	-----	0.05	1.2
Minerals						
Calcium	mg	13	11	10	55	7
Iron	mg	0.39	0.39	0.9	2.66	0.38
Magnesium	mg	10	8	9	32	5
Phosphorus	mg	23	13	19	71	9
Potassium	mg	259	138	229	1162	114
Sodium	mg	1	4	4	10	3
Zinc	mg	0.2	0.11	0.1	0.39	0.9
Copper	mg	0.078	0.079	0.064	0.343	0.073
Manganese	mg	0.077	0.052	0.05	0.235	0.032

USDA (2009)

Materials and methods

Fruit samples of "Jumbo cot", "Tom cot", "Goldstrike" , "Goldbar", "Bergeron", "Bergarouge", "Sweet cot", "Yellow cot" and "Zebra" apricot cultivars cultivated at the Boldogkőváralja commercial orchard of Hungary were harvested at eating maturity stages. Three homogenate samples of fresh and dried fruits were used for chemical analysis. Sample preparing was in accordance with Hungarian standard (MSZ-08-1783-15:1985). Fruits without peeling were digested with concentrate HNO_3 – H_2O_2 digester mixture 0.5 g fresh fruit 2 g dehydrated fruit) was digested at 120 °C during three hours in a Teflon digester. Digested samples diluted with distilled water to 100 cm^3. Examined elements were measured by Thermo Jarrell Ash Poly-scan 61E and Thermo Electron Corporation IRIS Intrepid II XDL Inductively coupled plasma emission spectrophotometers (ICP).

Daily Intake of Metals (DIM): To evaluate this factor, following equation was used.

$$DIM= C_{metal} \times C_{factor} \times D_{food\ intake} / B_{average\ weight}$$

Where, C_{metal} is heavy metals conc. in plants (mg/kg), C_{factor} is conversion factor to change fresh weight to dry weight, $D_{food\ intake}$ is daily intake of fruit, $B_{average\ weight}$ is body weight.

Hazard Quotient (HQ): This is a ratio of determined dose to the reference dose (R*f*D). The population will pose no risk if the ratio is less than 1 and if the ratio is equal or greater than 1 then population will experience health risk. This risk assessment method has been used by researchers

(*Sridhara,* 2008; *Chien,* 2002 and Wang, 2005) and proved to be valid and true. The following equation is used;

$$HQ = [W_{plant}] \times [M_{plant}] / R_fD \times B$$

Where W_{plant} is the dry weight of contaminated plant material consumed (mgd^{-1}), M_{plant} is the plant concentration of metal in vegetables ($mg\ kg^{-1}$), R*f*D is the food reference dose for the metal (mgd^{-1}) and B is the body mass (kg) (khan, 2009).

Health Risk Index (HRI): By using Daily Intake of Metals (DIM) and reference oral dose the health risk index were obtained.

$$HRI = DIM / RfD.$$

If the value of HRI is less than 1 then the exposed population is said to be safe (*Khan,* 2008).

Results

Analysis of samples for Hazardous elements show that concentration of As, Cd, Hg and Pb in all studied apricot cultivars were less than 0.2, 0.016, 0.6 and 0.2 mg/kg for fresh and 0.5, 0.04, 1.5 and 0.5 mg/kg for dried samples. Which was lower than limited concentration of those heavy metals in food except for Cd concentration of dry samples (*Table 2*).

Cadmium is a highly toxic metal with a natural occurrence in soil, and also spread in the environment due to human activities (*Alam,* 2003). Cadmium has no beneficial effect on human health. Its known acute toxicity and long half-life even up to 30 years in human body and could be dangerous under conditions of severe or prolonged exposure (*Wagner,* 1993). The concentration of Cd ion was found in the range of 0.09–0.21 mg/kg in apricot of Pakistan by *Zahoor* et al. (2003) and in range of 0.02–0.72 mg/kg in the apricots of Turkey by *Saracoglu* et al. (2009) while the average of 9 examined cultivars in Hungary was less than 0.04 mg/kg.

Lead is a cytoplasmatic poison, which reacts with SH groups of enzymes and cellular proteins damaging nervous (hearing nerve), osseous (the main place of accumulation) and blood systems, as well as kidneys and alimentary canal)

Table 2. World limit for soil contamination and daily uptake of trace elements in food and highest concentration of Hazardous elements in all examined apricots cultivars.

	World limit for soil (mg/kg)1	World limit for daily uptake mg/kg body weight/day[2]	Limit per kg of food (mg/kg)[2]	Highest concentration in all examined cultivars (mg/kg)
Cd	0.35	2.5	0.5	0.04
Hg	0.3	1.5	1.5	1.5
Pb	35	1	5.5	0.5
As	10	1.5	3	0.5

[1]*Coskun et al., 2006.*
[2]*USDA., 2009.*

Ernst, 2002; *Duran* et al. (2009) reported 12.4 mg/kg Pb in dried samples of apricot in Turkey. *Zahoor* et al., 2003, reported 1.66 mg/kg of Pb in apricots of Pakistan. The level of Pb ion in our samples was lower than Pb levels in foodstuffs of Pakistan and Turkey.

Arsenic is a very toxic metalloid. It has a serious impact on the human health. The inorganic form of As is toxic to human being. Arsenic and trace metal can inter into the plants from soil and hence in food chain from contaminated soil and may infect human being as well (*Zhang* et al., 2002). There is substantial evidence that Arsenic increases risk of cancer of the bladder, lung, skin, and prostate. (*USA National Research Council,* 2001). Food is also a potentially important source of dietary Arsenic intake (*Schoof,* 1999). *Creger* (1992) reported 70 mg/kg of arsenic concentration in fresh samples of apricot fruits. In this study apricot fruits arsenic level is higher than his results.

Mercuric poisoning on account of consumption of agricultural crops has been reported (in Iraq), but was due to consumption of seeds treated with mercuric fungicides (*Bakir* et al., 1973). Levels of Hg in most field crops are sufficiently low to cause little concern from a human health viewpoint (*Wiersma,* 1986). *Passos* et al. (2007) report the protective effect of fruit consumption for Hg exposure in Amazonian riparian's. *Todic* et al. (2006) also report normal Hg levels in grape vine in both polluted and non-polluted regions of Serbia. In this study also we found low levels of Hg concentration in apricots which may not really harm human health.

Food reference doses, HRI, DIM and HQ calculated for examined Hungarian apricot cultivars *(table 3.)* show that using 100 g of dried apricots daily for a 60 kg human may pose the exposed population by some problems which made by Hg and As toxicity. *Ferré-Huguet* et al. (2008) also reported Arsenic high HQ (more than 1) for Consumption of Vegetables, Fruits, and Rice in Catalonia, Spain.

Table 3. Food reference doses, HRI, DIM and HQ calculated for examined Hungarian apricot cultivars.

	R*f*D (mg/person/day)[1]	DIM	HQ	HRI
Cd	5.00E-04	6.66E-05	1.33E-01	1.33E-01
Hg	1.00E-04	2.50E-03	2.50E+01	2.50E+01
Pb	3.50E-03	8.30E-04	2.38E-01	2.38E-01
As	3.00E-04	8.30E-04	2.78E+00	2.78E+00

DIM was calculated for consumption of 100 g of dry apricots.
Body weight used was 60 kg.
[1]*USDA., 2009.*

Conclusion

Fruits are important source of nutrients and offer advantages over dietary supplements, because of low cost and wide availability. In daily diet fruits have been strongly associated with reduced risk for some forms of cancer, heart disease, stroke and other chronic ailments. In conclusion this study show that Hazardous element content of 9 examined apricot cultivars were less than world limit and daily intake of fresh or dried apricots may not cause serious problems. As the human health is directly affected by consumption of fruits and vegetables, The distribution of toxic elements their concentration and migration via from atmosphere, aqueous, fertilizers, pesticides and soil should be continued in the fleshy fruits. because of their importance to human food chain.

Reference

Ademoroti, M.C.A. (1986): Levels of heavy metals on bark and fruit trees in Benin City, Nigeria.Environmental Pollution Series B, 11: 241–253.

Alam, M.G.M., Snow, E.T. & Tanakab, A. (2003): Arsenic and heavy metal contamination of vegetables grown in Samta village, Bangladesh. Sci. Total Environ., 308: 83–96

Arora, M., Kiran, B., Rani, Sh. & Rani, A. (2008): Heavy metal accumulation in vegetables irrigated with water from different sources., 111 (4): 811–815

Bakir, F., Damluji, S., Amin-Zaki, L., Murtadha, L., Khalidi, A., AlRawi, N., Tikriti, S., Dhakhir, H., Clarkson, T.W., Smith, J. & Doherty, R., (1973): Methylmercury poisoning in Iraq. An Inter university Report. Science, 181: 230–241.

Bordajandi, L.R., Gomez, G., Abad, E., Rivera, J., del Mar Fernandez-Baston, M., Blasco, J. & Gonzalez, M.J. (2004): Survey of persistent organochlorine contaminants (PCBs, PCDD/Fs, and PAHs), heavy metals (Cu, Cd, Zn, Pb, and Hg), and arsenic in food samples from Huelva Spain: levels and health implications. J Agric Food Chem., 52: 992–1001

Creger, T.L. & Peryea, F.J. (1992): Lead and arsenic in two apricot cultivars and in 'Gala' apples grown on lead arsenic-contaminated soils. *HortScience,* 27: 1277–1278.

Chien, L.C., T.C. Hung, K.Y. Chaong, C.Y. Yeh, P.J. Meng & Shieh, (2002): Daily intake of TBT, Cu, Zn, Cd, nd As for fishermen in Taiwan. Sci. Total Environ., 285: 177–185.

Coskun, M., Steinnes, E. & Viladimirovna, F. (2006): Heavy metal pollution of surface soil in the Thrace region, Turkey. Environ Moni Assess, 119: 545–556.

D'Mello, J.P.F., (2003): Food safety: Contaminants and Toxins. CABI Publishing, Wallingford, Oxon, UK, Cambridge, MA 480p.

Duran, A., Tuzen, M. & Soylak, M. (2007): Trace element levels in some dried fruit samples from Turkey.International Journal of Food Sciences and Nutrition, 59. (7): 581 – 589

Eckel, H., Roth, U., Döhler, H., Nicholson, F. & Unwin, R. (2005): Assessment and reduction of heavy metal trace metal input into agro-ecosystems. Final report of EU-concerted action. AROMIS. KTBL-Schrift 432. Darmstadt, Germany: Kuratorium für Technik und Bauwesen in der Landwirtschaft e., 3: 7843–2176

Ernst, E. (2002): Heavy metals in traditional Indian remedies. European Journal of Clinical Pharmacology, 57: 891–896.

Ferré-Huguet, N., Martí-Cid, R., Schuhmacher, M. & Domingo, J. (2008): Risk Assessment of Metals from Consuming Vegetables, Fruits and Rice Grown on Soils Irrigated with Waters of the Ebro River in Catalonia, Spain. Biol. Trace Elem. Res., 123: 66–79.

Gorinstein, S., Martýn-Bellosob, O., Parkc, Y.S., Haruenkitd, R., Milanĉýž, A.L., Caspi, A., Libmanf, I. & Trakhtenbergf, S., (2001): Comparison of some biochemical characteristics of different citrus fruits. Food Chemistry 74: 309–315.

Gratani, L. & Varonea, L. (2008): Long-term monitoring of metal pollution by urban trees. Atmospheric Environment. 42. (35): 8273–8277.

Hui, Y.H. (2006): Handbook of Fruits and Fruit Processing , 1st ed. Blackwell Publishing, Oxford, 279–291 p.

Khan, S., Q.Y.Z. Cao, Y.Z. Huang & Y.G. Zhu., (2008): Health risks of heavy metals in contaminated soils and food crops irrigated with wastewater in Beijing, China. Environ. Poll., 125. (3): 686–692.

Khan, S. & Farooq, R., (2009): Health Risk Assessment of Heavy Metals for Population via Consumption of Vegetables, World Applied Sciences Journal, 6. (12): 1602–1606.

Li, J.T., Qiu, J.W., Wang, X.W., Zhong, Y., Lan, C.Y. & Shu, W.S., (2006): Cadmium contamination in orchard soils and fruits tree and its potential health risk in Guangzhou, China. Environmental Pollution, 143: 159–165.

Li, P. & Wang, X. (2009): Risk assessment of heavy metals in soil previously irrigated with industrial wastewater in Shenyang, China.Journal of Hazardous Materials 161: 516–521.

Lugon-Moulin, N., Ryan, L., Donini, P. & Rossi, L. (2006): Cadmium content of phosphate fertilizers used for tobacco production. Agron Sustain Develop., 26: 151–5.

Munzuroglu, O., Karatas, F. & Geckil, H., (2003): The vitamin and selenium contents of apricot fruit of different varieties cultivated in different geographical regions, Food Chem., 83: 205–212.

Parveen, Z., Khunhro, M.I. & Rafig, N. (2003): Market basket survey for lead, cadmium, copper, chromium, nickel and zinc fruits and vegetables. Bulletin of Environmental Contamination and Toxicology., 71: 1260–1264.

Passos, C.J.S. & Mergler, D. (2007): Epidemiologic confirmation that fruit consumption influences mercury exposure in riparian communities in the Brazilian Amazon, Environ Res, 105: 183–193.

Pinochet, H., De Gregori, I., Lobos, M.G. & Fuentes, E. (1999): Selenium and copper in vegetables and fruits grown on long term impacted soils from Valparaiso Region, Chile. Bulletin of Environmental Contamination and Oxicology., 63: 327–334.

Rieger, M. (2004): Mark's Fruit Crops Homepage, University of Georgia (http://www.uga.edu/fruit).

Rossini Oliva, S. And Valde´s, B., (2003): Metal concentrations in Seville orange (Citrus aurantium) fruits from Seville (Spain) and Palermo (Italy. Annales Botanici Fennici, 40: 339–344.

Santos, E.E., Lauria, D.C. & Porto da Silveiro, C.L., (2004): Assessment of daily of trace elements due to consumption of foodstuffs by adult inhabitants of Rio de Janeiro city. Science of the Total Environment, 327: 69–79.

Saracoglu, S., Tuzenb, M. & Soylakc, M. (2009): Evaluation of trace element contents of dried apricot samples from Turkey, Journal of Hazardous Materials, 167: 647–652

Schoof, R. A., Yost, L. J., Eickhoff, J., Crecelius, E. A., Meacher, D. M. & Menzel, D. B. A (1999): Market basket survey of inorganic arsenic in food. Food Chem. Toxicol., 37: 839–846.

Selema, M.D. & Farago, M.E., (1996): Tarce element concentrations in the fruit peels and trunks of Musa paradisiacal. Phytochemistry, 42 (6): 1523–1525.

Sridhara, Chary, N., C.T. Kamala & D. Samuel Suman Raj, (2008): Ecotoxicol. And Environ. Safe., 69. (3): 513–524.

Todic, S., Beslic, Z. & Lakic, N. (2006): Lead, Mercury, and Nickel in Grapevine, Vitis vinifera L., in Polluted and Nonpolluted Regions. Bull. Environ. Contam. Toxicol., 77: 665–670

USA National Research Counc (2001): Arsenic in Drinking Water Update; National Academies Press: Washington, DC.

USDA National Nutrient Database for Standard Reference. **(2009** (http://www.ars.usda.gov

Wagner, G.J. (1993): Accumulation of cadmium in crop plants and its consequences to human health. Advances in Agronomy, 51: 173–212.

Wang, X., T. Sato, B. Xing & S. Tao, (2005): Health risks of heavy metals to the general public in Tianjin, China via consumption of vegetables and fish. Sci.Total Environ., 350: 28–37.

Ward, N.I. & Savage, J.M., (1994): Metal dispersion and transportational activities using food crops as biomonitors. Science of the Total Environment, 146/147: 309–319.

Wiersma, D., van Goor, B.J. & van der Veen, N.G., (1986): Cadmium, lead, mercury and arsenic concentrations in crops and corresponding soils in the Netherlands. J. Agric. Food Chem., 34: 1067–1074.

Williams, J.R., Pillaya, A.E. & El Mardi, M.O. (2005): Levels of selected metals in the Fard cultivar (date palm) Journal of Arid Environments, 60: 211–225

Zahoor, A. & Zahoor, M. (2003): Elemental distribution in summer fruits of Pakistan, Nutr. Food Sci., 33: 203–207.

Zhang, W., Yong, CY. & Tub, C. (2002): Arsenic speciation and distribution in an arsenic hyper accumulating plant. Sci Total Environ, 300: 167–177.

Zhuang, P. **& McBride, M**.**B (2009):** Health risk from heavy metals via consumption of food crops in the vicinity of Dabaoshan mine, South China, Science of the total invoironment, 407: 1551–1561.