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Hazardous element content and consumption risk of 9 apricot cultivars

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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 HNO₃ – H₂O₂ 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 obtained 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 Hungary 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)

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 Boldgkővára 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 cm³. 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.

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

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

Hazard Quotient (HQ): This is a ratio of determined dose to the reference dose (RfD). 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

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
<i>Proximate</i>						
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
<i>Vitamines</i>						
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
<i>Minerals</i>						
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

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

$$HQ = [W_{\text{plant}}] \times [M_{\text{plant}}] / R_f D \times B$$

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.

$$HRI = \text{DIM} / R_f D.$$

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

¹Coskun et al., 2006.

²USDA., 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.

	RfD (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.

¹USDA., 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.

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