

## Trace Elements Measurement In Apricot (*Prunus Armeniaca L.*) Seeds By Neutron Activation Analysis

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### Abstract

Plant food are main sources of elements in human nutrition diet and required for proper growth and body development. Present study involved analyzing the elemental profile attributes of apricot seeds in order to obtain a global pattern of apricot seeds. Trace element in seed of 8 apricot cultivars grown in Syria have been determined using Instrumental Neutron Activation Analysis (INAA). Total of 28 elements namely Potassium (K), Magnesium (Mg), Calcium (Ca), Chlorine (Cl), Sodium (Na), Zinc (Zn), Iron (Fe), Copper (Cu), Aluminum (Al), Manganese (Mn), Rubidium (Rb), Iodine (I), Bromine (Br), Cobalt (Co), Antimony (Sb), Molybdenum (Mo), Chromium (Cr), Mercury (Hg), Barium (Ba), Cadmium (Cd), Cerium (Ce), Lanthanum (La), Selenium (Se), Samarium (Sm), Strontium (Sr), Titanium (Ti), Uranium (U) and Vanadium (V) were determined. The elements present in the apricot seed samples were in the range of levels reported in the literature. The results show that the seed of apricot cultivars grown in Syria is rich in the essential macro and micro-nutrients that are of important in dietary point of view.

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## Introduction

Plants food for human nutrition are the richest source compared to animal ones of many compounds like flavonoids, polyphenoles, polysaccharides, terpenoids, alkaloids, quinones, carotenoids, sterols, glucosinolates and other sulphur-containing compounds essential elements etc. [1,2,3].

Plant foods are main sources of elements in human diet and are required for proper growth and body development [4,5,6]. Elements may be classified from a dietary point of view as essential trace elements (macro or major elements); the possibly essential trace elements (micro elements); and the non-essential trace elements (ultra trace elements) which are toxic and non-toxic elements [5]. The macro-elements are required in amounts greater than 100 mg/dl and the micro-elements are required in amounts less than 100 mg/dl [7]. The ultra trace elements have been found in animals and are believed to be essential for animals [8]. Humans need more than 22 elements; some of them are required in large amounts, but others are required in trace amounts because higher concentrations can be harmful [9]. Required amounts of these elements must be in human diet to purpose a good healthy life [10]. A number of trace elements protect the cell in the tissue from oxidative as these elements are the co-factor of antioxidant enzymes [11,12]. It is known that elements cannot be synthesized by the human body, and can only be obtained from the consumption of certain foods particularly natural and green ones which were recognized, through the utilization of techniques developed for the sensitive detection of trace elements, as important sources of these elements [13].

Trace elements are usually quantified by spectrometric techniques [14,15,16]. Other techniques such as neutron activation analysis (NAA) is also applied to plant samples [17]. The NAA technique is a quantitative and qualitative method of high efficiency for precise determination of about 25-30 elements of different types of samples in ppb or ppm (part per billion or part per million) range [18]. In this technique, the sample is exposed to neutron flow after which radioactive isotopes for interest element are generated. The radioactive emission and radioactive decay paths

for each elements are well known [14]. Previously neutron activation analysis for comparative study of minor and trace elements in cereals [5]. NAA was successfully applied to determine trace and minor element content in medicinal plants [19] and food stuff [20].

There is limited information on the element content of numerous plant foods consumed in some less developed countries, like Syria [8,13]. According to many studies, elements were affected by climate, variety, soil properties, geographical origin, genetic factors, harvesting time, harvest year, methods of cultivation and variations and analytical procedures [21,22]. According to our best knowledge, there exist no previous studies of the element content of Syrian food crops. We have therefore carried out this work in order to have an up to date knowledge on locally food that produced in Syria. The kernel of apricot seeds are a valuable by-product. Owing to the presence of unsaturated fatty acids in good portion, its quality attributes matches with almond oil [23]. Sweet kernels taste like almond and are usually consumed in Syria as a fresh snack or as an important ingredients in some traditional Syrian meals. Also, the apricot seeds and its oil can be used in the cosmetics, food and drug industry [24,25]. To ensure dependable work, we have adopted the Instrumental Neutron Activation Analysis (INAA) due to its advantages of low detection limit and multi elemental capability. So the objective of this investigation was to evaluate the elemental profile attributes of seeds of eight cultivars of apricot locally grown in Syria using neutron activation analysis (NAA).

## Materials and Methods

### *Sampling and Sample Preparation*

Seeds of 8 apricot cultivars comprising of Kullabi, Tadmori, Ajjami, Lawzi, Wizri, Hamwi laqisi, Hamwi Shahmi, and Baladi were investigated. However, Kullabi, Tadmori, Ajjami, Lawzi, Wizri, Hamwi laqisi, Hamwi Shahmi, and Baladi are the common name of local Syrian cultivars belong *Prunus armeniaca* related to family *Rosaceae*. Apricot fruits (*Prunus armeniaca*) were purchased at local grocery store in Damascus the capital city of Syria. The fresh fruit samples were transported to the laboratory where the stones were removed and individual stones were hammered to obtain the seed

kernel. The apricot seeds were visually inspected and defective seeds were discarded. Next, the non-edible parts were removed, and the kernels were oven dried at 70-80°C until they reached a constant weight. They were then grounded and sieved through an 80 mesh sieve to have their powder. Dry mass factor was calculated by drying the powder for 4 hours at 105 °C. The sample size, however, was considered reasonably well enough for the purpose of the study. The determinations were made in triplicate for each apricot cultivar seed samples.

#### *Irradiation and Counting*

First the short-lived nuclides were determined. Using a pneumatic rabbit system, approximately 200 mg from each sample was irradiated separately (but the standard reference material together with two comparators in order to calculate the neutron flux) for 60 seconds at a thermal neutron flux of  $5 \times 10^{11} \text{ n.cm}^{-2}\text{s}^{-1}$  in inner irradiation site at Miniature Neutron Source Reactor (MNSR) Slowpoke Nuclear Research Reactor (is a low-energy) (tank-in-pool type, China). After 300-600 second decay time samples and standard reference material were measured on 75 mm from end cap of detector, comparators (Al-0.1% Au) were measured separately after 20 minutes decay time on 200 mm from end-cap of detector.

Second the other elements with longer half life times were determined. A maximum of 8 capsules filled with sample material (~200 mg), together with a two capsule filled with a certified reference material and four comparators were ordered in irradiation container. The samples were irradiated for 20 hours at a thermal neutron flux of about  $5 \times 10^{11} \text{ n.cm}^{-2}\text{s}^{-1}$ . To determine the elements with medium lived radio-nuclides, all samples were measured for 30-60 minutes after 5 to 10 days decay time after irradiation on 25 mm from the end-cap detector. To determine the long lived radio-nuclides, the samples are measured again for 8 hours after about 3 weeks decay time after irradiation directly on the top of detector. Comparators (Al-0.1% Au) were measured separately after 5 days decay time on 200 mm from end-cap of detector. After this third measurement, all 3 spectra of each sample are interpreted together by using k0-IAEA software.

Samples were measured by using gamma spectroscopy: HPGe detectors 25% relative efficiency, FWHM1.79 at 1.333 MeV, with Selina gammapl software version(1.02), the peak search, the energy gamma system were calibrated by using point source radioactive (such as :  $^{152}\text{Eu}$ ,  $^{137}\text{Cs}$ ,  $^{60}\text{Co}$ , ...etc). The results were controlled using Nist 1547 peach leaves and Nist 1515 Apple leaves as standard reference methods.

#### **Results and Discussion**

The NAA analytical technique allowed us to obtain the concentration of 28 elements in seed of eight apricot cultivars grown in Syria. The major elements (K, Mg, Ca, Cl) and the trace elements (Zn, Fe, Na, Cu, Al, Mn, Rb, I, Br, Co, Sb) were detected in all the apricot seed samples. While the trace elements of Mo, Cr, Hg were detected in some samples. The real trace elements of Ba, Cd, Ce, La, Se, Sm, Sr, Ti, U and V were found to be below detection limit.

#### *Overall Essential Major (Macro) Elements Concentrations in Apricot Seed Samples*

The element contents in the seed of eight apricot cultivars showed that Potassium (K), Magnesium (Mg), Calcium (Ca), Chlorine (Cl), and Sodium (Na) were established as major elements. Table 1 presents the results of K, Mg, Ca, Cl and Na in the seed of eight apricot cultivars grown in Syria. The contents of K, Mg and Ca in apricot seed are in a range of 8342-17210 mg/kg, 3057-4252 mg/kg, and 2104-3256 mg/kg, with an overall average K, Mg and Ca concentration of 14485 mg/kg, 3928 mg/kg, and 2823 mg/kg, respectively. As shown in Table 1, apricot seeds are an excellent source of K, Mg, and Ca. However, minerals contents including K, Mg, Ca and Na were determined to vary widely depending on the different cultivars and locations of plant. The soil, fertilizers, cultivars and other cultural factors affect the presence of minerals in oil seeds [21]. The present element analysis results were in agreement with those of Manzoor et al. [26] who reported that K was the most abundant nutrient in fruits of different peach varieties, followed by Mg and Ca. Available data indicate that major mineral elements of apricot are Ca, Fe, K, Mg, Na, P and Al [25]. Haciseferogullari et al. [27] determined concentrations of K in apricots in the range of 33.3646–22.029 mg/kg. Generally, the concentrations

Table 1. Major elements concentrations (K, Mg, Ca, Cl and Na) in Syrian apricot seed (mg/kg).

Element	K		Mg		Ca		Cl		Na	
Cultivars	Value±Unc	LOD	Value±Unc	LOD	Value±Unc	LOD	Value±Unc	LOD	Value±Unc	LOD
Kullabi	8342±150	66.26	3057±168	106	2683±950	475	115.50±10.86	48	23.64±0.50	0.66
Tadmori	17210±224	66.26	3744±150	106	2655±954	475	148.20±11.18	48	18.18±0.75	0.66
Ajjami	15510±217	66.26	3910±133	106	2926±732	475	158.80±13.97	48	21.82±1.79	0.66
Lawzi	16140±307	66.26	4198±139	106	3055±397	475	125.30±11.65	48	31.01±1.71	0.66
Wizri	15350±338	66.26	4071±114	106	2999±399	475	453.80±22.69	48	35.03±1.37	0.66
Hamwi leqissi	15810±443	66.26	3985±116	106	2104±267	475	113.90±19.14	48	22.74±1.14	0.66
Hamwi shahmi	14730±457	66.26	4205±143	106	3256±723	475	84.11±9.25	48	39.51±2.53	0.66
Baladi	12790±294	66.26	4252±119	106	2595±348	475	104.60±8.89	48	15.51±1.07	0.66
Average	14485±304		3928±135		2823±478		163±14		25.93±1.35	

LOD: Limit of Detection , Unc: Uncertainty

Table 2. Concentration of some trace elements (Zn, Fe, Cu, Al, and Mn) in Syrian Apricot Seed (mg/kg)

Element	Zn		Fe		Cu		Al		Mn	
Cultivars	Value±Unc	LOD	Value±Unc	LOD	Value±Unc	LOD	Value±Unc	LOD	Value±Unc	LOD
Kullabi	95.43±3.91	0.5	66.97±4.75	12	22.52±6.17	6.5	16.14±1.05	1.8	10.28±1.15	0.66
Tadmori	106.40±21.39	0.5	77.66±7.92	12	27.86±6.38	6.5	18.36±1.18	1.8	13.99±1.13	0.66
Ajjami	84.52±4.14	0.5	73.36±4.47	12	24.28±5.95	6.5	18.14±1.07	1.8	14.60±0.63	0.66
Lawzi	98.00±14.31	0.5	78.98±6.00	12	22.69±8.42	6.5	17.86±0.82	1.8	13.83±0.77	0.66
Wizri	112.80±15.57	0.5	75.05±4.73	12	24.32±4.47	6.5	15.91±1.15	1.8	17.46±0.68	0.66
Hamwi leqissi	92.0±13.0	0.5	63.81±15.38	12	18.59±4.42	6.5	13.23±0.90	1.8	13.14±0.50	0.66
Hamwi shahmi	96.45±8.39	0.5	65.16±5.93	12	20.58±4.49	6.5	18.95±0.95	1.8	11.16±0.52	0.66
Baladi	88.26±13.59	0.5	59.06±8.62	12	21.98±2.84	6.5	13.06±0.74	1.8	14.05±0.62	0.66
Average	97.41±11.61		70.01±7.23		22.85±5.39		16.46±0.98		13.56±0.75	

LOD: Limit of Detection , Unc: Uncertainty

of Ca and Mg in total of 49 food samples comprising of 16 fresh fruits, 17 fresh vegetables, 4 herbs, and 12 processed foods ranged between 97-4970 mg/kg, and 18.1-236.8 mg/kg, with an overall average Ca and Mg concentrations of 1501 mg/kg and 186.5 mg/kg respectively [4]. Ca is an essential element for human health, participation in the biological functions of several tissues [9]. Ca has been proven clinically associated with reduced risk of various non-communicable diseases [28]. The consumption of crops rich in K is recommended for the prevention of cardiovascular or oncogenic disease [29]. Together with Na this element is involved in regulation of osmotic pressure [8,30]. The Mg is an essential element acts as a Ca antagonist on vascular smooth muscle tone and on post-receptor insulin signaling [31]. In addition, Mg participates with muscle and as a cofactor of up to 300 enzymes [32].

The present study shows that the content of Sodium (Na) in apricot seed ranged from 15.51 mg/kg (Baladi cultivar) to 39.51 mg/kg (Hamwi leqissi), with an overall average Na concentration of 25.93 mg/kg. The concentrations of Chlorine (Cl) in all apricot seeds ranged between 84.11 mg/kg (Hamwi leqissi) and 458.80 mg/kg (Wizri), with overall average Cl concentration of 163 mg/kg. The role of Na in human physiology is related to the maintenance of the balance of physiological fluids [33]. The recommended intake for Na is 2400 mg per day [9]. According to United State Department of Agriculture (USDA) the daily recommended intake (RDA) for Na and K intake is not more than 2.400 mg and 4.700 mg respectively per day [9,34]. Low Na concentration and the presence of a great amount of K suggest the use of apricot seeds in an anti-hypertensive diet [35]. K is important for its diuretic nature and Na plays an important role in the transport of metabolites. The ratio of K/Na in any food is an important factor in prevention of hypertension arteriosclerosis, with K depresses and Na enhances blood pressure [36]. In the present study K/Na, also show positive relation.

#### *Overall Essential Micro (trace) Elements Concentrations in Apricot Seed Samples*

The overall concentrations of the trace elements in all seed samples of eight apricot cultivars grown in Syria are shown in Tables 2 and 3. An overall average

concentration of Zinc (Zn) (97.41 mg/kg), Iron (Fe) (70.01 mg/kg), Copper (Cu), (22.85 mg/kg), Aluminum (Al), (16.46 mg/kg), Manganese (Mn) (13.56 mg/kg), Rubidium (Rb) (7.84 mg/kg), Iodine (I) (5.21 mg/kg), Bromine (Br) (1.24 mg/kg), Cobalt (Co) (0.34 mg/kg), and Antimony (Sb) (0.02 mg/kg) were recorded in the apricot seed samples.

Trace elements are also called micro elements which are required in amounts less than 100 mg/day [7].

#### *Zinc (Zn):*

The trace element contents in these eight apricot varieties showed that Zn was the most abundant micro (trace) element, ranging from 84.52 mg/kg (Ajjami cultivar) to 112.80 mg/kg (Wizri cultivar). While concentration of Zn was below detection limit in Hamwi shahmi apricot seeds. Also, lower concentrations of Zn and Mn were recorded in apricot [6].

Zn is known to be involved in most metabolic pathways in humans, and Zn deficiency can lead to loss of appetite, growth retardation, skin changes, and immunological abnormalities. Zn reported as a coenzyme for over 200 enzymes involved in body immunity system [26]. RDA for Zn (8 mg/day for adult women and 11 mg/day for adult men) appears sufficient to prevent deficiency in most individuals [37].

#### *Iron (Fe):*

The range of Fe in all studied apricot seed samples varies from 59.06 mg/kg (Baladi cultivar) to 78.98 mg/kg (Lawzi cultivar). The permissible limit Fe set by FAO/WHO in edible plants was 20 µg/g [38]. According to USDA the daily recommended intake (RDA) of Fe is 8 mg for adult male and 18 mg for adult female [34]. Fe is an important trace element and is a core of red blood cells. It's deficiency can cause anemia [32,39].

#### *Copper (Cu):*

The lowest concentration of Cu that is 18.59 mg/kg (Hamwi laqisi cultivar) and maximum concentration estimated 27.86 mg/kg (Tadmori cultivar). The permissible limit of Cu set by FAO/WHO [40] in edible plants was 3.00 mg/kg [39]. After comparison, element limit in the studied apricot seed samples with those proposed by FAO/WHO [40] it is

Table 3. Concentration of some trace elements (Rb, I, Br, Co and Sb) determined by INAA in Syrian apricot seed (mg/kg).

Element	Rb	I	Br	Co	Sb	DL
	Value±Unc	Value±Unc	Value±Unc	Value±Unc	Value±Unc	
Cultivars						
Kullabi	2.94±0.30	1.90±0.43	0.55±0.58	0.41±0.01	0.049±0.004	0.007
Tadmori	8.94±0.31	1.93±0.39	0.89±0.66	0.18±0.01	0.017±0.004	0.007
Ajjami	5.51±0.22	1.57±0.48	3.28±0.65	0.67±0.01	0.017±0.005	0.007
Lawzi	3.59±0.17	1.69±0.55	0.68±0.68	0.20±0.01	0.017±0.005	0.007
Wizri	7.56±0.26	30.67±1.20	0.80±	0.38±0.01	0.033±0.008	0.007
Hamwi leqissi	17.45±0.73	1.63±0.30	< LOD	0.40±0.01	0.013±0.003	0.007
Hamwi shahmi	12.37±0.41	1.06±0.30	< LOD	0.23±0.01	0.012±0.004	0.007
Baladi	4.39±0.23	1.21±0.29	< LOD	0.28±0.01	0.027±0.004	0.007
Average	7.84±0.33	5.21±0.49	1.24±0.64	0.34±0.01	0.02±0.005	

LOD: Limit of Detection , Unc: Uncertainty

found that all seed samples accumulate Fe and Cu above this limit. Cu is a constituent of enzymes like cytochrome c oxidase, amine oxidase, catalase, peroxidase, ascorbic acid oxidase, cytochrome oxidase, plasma monoamine oxidase, lactase, uricase, tyrosinase, cytosolic superoxidase dismutase etc [8].

#### *Aluminum (Al):*

Al is the most widespread metal on the Earth (8% of Earth crust), and nearly all foods contain small amount Al. The daily average intake of Al estimated vary from 2 to 10 mg/day [41]. The range obtained from Al in this study was (13.06 mg/kg) (Baladi cultivar) to (19.81 mg/kg) (Hamwi leqissi). These values are higher than those reported in other research papers for a total of sixteen (16) cereals samples [5]. There is concern because of the possibility of increased amounts of Al being deposited in the brain and implicated as interfering with a variety of cellular and metabolic processes [5].

#### *Manganese (Mn):*

The range of Mn in all studied apricot seed samples varies from 10.28 mg/kg (Kullabi cultivar) to 17.46 mg/kg (Wizri cultivar). Mn is a cofactor of hydrolase, decarboxylase, and transferase enzymes [7]. Mn is a component of arginase and superoxide dismutase and plays a role as co-factor of certain enzymes [20,37]. The USDA has recommended an intake of Mn of 2.3 mg/day for adults male and 1.8 mg/day for female [34].

#### *Rubidin (Rb):*

The content of Rb in case of apricot seed was within 2.94 and 17.45 mg/kg for Kullabi and Hamwi leqissi, respectively. These values are lower than those reported in other research papers. According to Jibiri and Agomuo [42] Rb concentration in green beans, cassava, guinea corn and maize have been reported to be 85.5, 37.5, 41.7 and 20.7 mg/kg respectively.

#### *Iodine (I):*

The lowest concentration of I is 1.06 mg/kg (Hamwi shahmi cultivar) and maximum concentration estimated 30.67 mg/kg (Wizri cultivar). Iodine is a basic component of the thyroid hormones, thyroxine and mono-, di-, and tri-iodothyronine and it is stored in thyroid as thyroglobulin [7].

#### *Bromine (Br):*

The highest amount of Br was found in Ajjami cultivar seed (3.28 mg/kg) while the lowest amount of Br was found in seeds of Kullabi cultivar 0.55 mg/kg. Analysis of samples for Br show that concentration of Br in the Hamwi laqisi, Hamwi shahmi and Baladi cultivars were below detection limit.

#### *Cobalt (Co):*

The Co content of the studied apricot seeds varied from 0.18 mg/kg (Tadmori cultivar) to 0.67 mg/kg (Ajjami cultivar). The RDA for Co has been defined at around 300 micrograms [6]. Cobalt is required in the haematopoiesis of red blood cells and in preventing anemia [43].

#### *Antimony (Sb):*

The concentration of Sb in apricot seeds was very low and ranged from 0.012 mg/kg (Hamwi shahmi) to 0.049 mg/kg (Kullabi).

Various investigators have addressed the levels of essential and non essential trace elements from various vegetables, fruits, spices, herpes and food items [15,44,45]. Mehari et al. [4] reported that among total of 49 food samples comprising of 16 fresh fruits, 17 fresh vegetables, 4 herbs, and 12 processed foods the highest concentrations of Fe, Pb, Zn, and Mg were found in apricot, moringa, yellow yam, American okra, and Chinese okra respectively. The concentration or quantity of trace elements in crop depend on the soil in which the crop is grown [42,46]. The content of elements was found to vary widely depending on different cultivars of apricot [27]. The content of trace elements is one of the most essential aspects that influence the use of edible plant parts in human nutrition [30]. The presence of trace elements in plants is affected by nutrients and agrochemical inputs [15]. In general, minerals contents were determined vary widely depending on the different varieties, species, and locations of caper plants. The soil, fertilizers and other cultural factors affect the presence of minerals in seeds [21].

#### *Overall Non-Essential (toxic) Elements Concentrations in Apricot Seed Samples*

The non-essential (toxic) elements (Molybdenum (Mo), Chromium (Cr), Mercury (Hg)) concentration in seeds of 8 varieties of Syrian apricot are shown in

Table 4. Concentration of some toxic elements (Mo, Cr and Hg Rb) determined by INAA in Syrian apricot seed (mg/kg).

Element	Mo		Cr		Hg	
Cultivars	Value±Unc	LOD	Value±Unc	LOD	Value±Unc	LOD
Kullabi	0.48±0.13	0.2	< LOD	0.09	< LOD	0.09
Tadmori	< LOD	0.2	< LOD	0.09	< LOD	0.09
Ajjami	< LOD	0.2	< LOD	0.09	< LOD	0.09
Lawzi	< LOD	0.2	< LOD	0.09	< LOD	0.09
Wizri	0.67±0.17	0.2	0.20±0.05	0.09	0.38±0.03	0.09
Hamwi leqissi	< LOD	0.2	0.35±0.11	0.09	< LOD	0.09
Hamwi shahmi	1.24±0.30	0.2	< LOD	0.09	< LOD	0.09
Baladi	< LOD	0.2	< LOD	0.09	< LOD	0.09
Average	0.80±0.20		0.27±0.08		0.38±0.03	

LOD: Limit of Detection , Unc: Uncertainty

Table 5. Concentration of trace elements in standard reference materials determined by INAA with their certified values (mg/kg).

Element	Nist 1547 peach leaves		Nist 1515 Apple leaves	
	This work results Value±Unc	Reference value Value±Unc	This work results Value±Unc	Reference value Value±Unc
AL	243.9±4.7	249±8	299.3±5.5	286±9
Br	10.5±0.17	11*	1.66±0.06	1.8*
Ca			14710±186	15260±150
Cl	366.2±19.6	360±19	556±28	579±23
Co	0.079±0.004		0.11±0.01	0.09*
Cr	1.58±0.24	1*		
Fe	224±8	218±14	85.6±18.6	83±5
K	23990±210	24300±300	15670±188	16100±200
Mg	4281±133	4320±80	2671±103	2710±80
Mn	98.78±1.58	98±3	53.±1	54±3
Rb	18.52±0.5	24±2	9.33±0.77	10.2±1.5
Sb	0.029±0.01	0.02*	0.024±0.01	0.013*
Zn	18.21±0.79	17.9±0.4	12.57±1.14	12.5±0.3

Unc: Uncertainty, \* these values non-certified



Table 4. Analysis of samples for toxic elements show that the overall average concentration of Mo, Cr and Hg in all studied seed samples of apricot cultivars were 0.80 mg/kg, 0.27 mg/kg and 0.38 mg/kg respectively. As shown in Table 4, Mo was present in three of the eight samples (cultivar) analyzed at concentration of a low of 0.48 mg/kg (Kullabi), 0.67 mg/kg (Wizri) and 1.24 mg/kg (Hamwi shahmi) (Table 4).

Molybdenum (Mo) is a component of several metalloenzyme including xanthine oxidase, aldehyde oxidase, nitrate reductase, and hydrogenase [7,8]. Chromium (Cr) was also present in two of the eight samples analyzed at concentration of a low of 0.20 mg/kg and 0.35 mg/kg in Wezri and Hamwi laqisi cultivars respectively. Most foodstuffs contain less than 0.1 mg Cr/kg [11]. It is well accepted that Cr is essential for normal blood glucose and lipid metabolism and insulin- co adjuvant [32]. Analysis of samples for Mercury (Hg) show that concentration of Hg in all studied seed of apricot cultivars were below detection limit in all the varieties except in Wezri cultivar (0.38 mg/kg). The permissible limit of Hg set by USDA in food was 1.5 mg/kg [47]. Levels of Hg in most field crops are sufficiently low to cause little concern from a human health viewpoint [47]. In this study also we found low levels of Mo, Cr and Hg concentration in apricot seeds of different apricot cultivars were lower than the permissible limits and therefore, do not represent a health risk. Some heavy metals are essential to maintain normal human body functions at trace amount. However, they may be dangerous or even toxic if present at higher concentrations [14]. Keeping in mind the potential toxicity and persistent nature of toxic elements, and the frequent consumption of fruits, it is necessary to analyze these food items to ensure the levels of these contaminants meet agreed international requirements [11]. Different reason may cause contamination of plant products with toxic elements. Using mineral fertilization, contaminated water, industrial emission and transportation, mining and processing metal ore are the main sources of toxic metal in agricultural system [48].

## Conclusion

The NAA analytical technique was used in the elemental analysis in seed of eight apricot cultivars

grown in Syria. Concentration of 25 elements were detected. The major and trace elements K, Mg, Ca, Cl, Zn, Fe, Na, Cu, Al, Mn, Rb, I, Br, Co, Sb were detected in all the apricot seed samples (Table 5). While the trace elements of Mo, Cr, Hg were detected in some samples. The real trace elements of Ba, Cd, Ce, La, Se, Sm, Sr, Ti, U and V were found to be below detection limit. All the elements are found to be below the recommended tolerable levels proposed by Joint FAO/WHO expert Commission on Food Additives. The results show that the apricot seed is rich in the essential macro and micro-nutrients that are of important in dietary point of view. Element compositions of apricot seeds are valuable information in understanding their functional, quality and nutritional properties.

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