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Monitoring of Element Contents of Three Different Apple (*Malus* Spp.) Varieties in an Apple Tree

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Abstract Elements of three different apples in an apple tree were determined by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES). K contents of apples ranged from 8510 mg/kg (green apple) to 11942 mg/kg (yellow-red apple). While Mg contents of three different apples change between 505 mg/kg (wild apple) and 734 mg/kg (wild apple), P contents ranged from 683 mg/kg (green apple) to 1145 mg/kg (yellow-red apple). In addition, S contents of apple samples were found between 413 mg/kg (green apple) to 556 mg/kg (yellow-red apple). B contents of apples were found between 18.8 mg/kg (wild apple) to 21.0 mg/kg (green apple). As a result, Cu, Fe, Mn, Mo, Zn, Ca, K and Mg contents of wild apple were found higher than those of results of other samples.

Keywords: *an apple tree, three variety, mineral, heavy metals, ICP-AES*

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1. Introduction

Apples are considered a good source of dietary minerals [1]. The nutritive value is well known and represents the variable content of sugar, proteins, ascorbic acid, and mineral substances. Therapeutic value of apple is well known for different illnesses (determines the absorption of gastric secretions, the elimination of toxins, has diuretic effect) [2,3]. The most of K accumulation in apple fruits was also observed by Nachtigall and Dechen [4]. Calcium and iron are macro elements with a secondary part in plant development but which influence the consumption quality of fruits in a fresh state [3]. According to Wojcik [5], apple fruit with low Ca status are sensitive to pathological diseases, even if they are stored in controlled atmosphere storage. Main minerals (Ca, K, Na, and Mg) and essential trace elements (Fe, Cu, Zn, and Mn) are very important in biological processes [6]. The role of iron, copper, and manganese, as very effective catalysts in the prevention and treatment of atherosclerosis and its complications, was underscored by Wills [7]. It was shown that Mg and K have been used in the prevention and treatment of life threatening arrhythmias, which are related to coronary atherosclerosis [8,9,10]. Dietary fibers, major phenolics, main minerals, and trace elements in persimmons and apples were analyzed [11]. Different fruits will exhibit different capacities due to the presence of different dietary antioxidants, such as vitamin C and E, carotenoids, flavanoids, and other phenolic compounds [1,12]. Fruits and vegetables are valuable sources of minerals [13,14]. In the earlier part of this century, scientists could qualitatively detect small amounts of several mineral elements in living organisms. Minor elements have very important functions and are believed to be key components of proteins such as haemoprotein and haemoglobin, which have essential biochemical functions, and of other essential enzyme systems [15]. The aim of this study was to monitor the macro and micro nutrients of three different apple varieties growing in a tree in Fargo in US.

2. Material and Methods

2.1. Material

Apple samples were collected from three different apple varieties grafted to a wild apple tree in a apple garden in Fargo province of US in September 2013. They were transferred to laboratory in cool bags. Fruits were washed with clear distilled water without being peeled off. They were kept in refrigerator by using.

2.2. Determination of Mineral

Provided apple samples were dried at 70°C in a drying cabinet with air-circulation until they reached constant weight. Later, about 0.5 g dried and ground samples were digested by using 5 ml of 65% HNO_3 and 2 ml of 35% H_2O_2 in a closed microwave system (Cem-MARS Xpress). The volumes of the digested samples were completed to

20 ml with ultra-deionized water, and mineral contents were determined by ICP AES (Varian-Vista, Australia). Measurements of mineral concentrations were checked using the certified values of related minerals in the reference samples received from the National Institute of Standards and Technology (NIST; Gaithersburg, MD, USA) [16].

2.3. Working Conditions of ICP-AES:

Instrument: ICP-AES (Varian-Vista).
RF Power: 0.7-1.5 kw (1.2-1.3 kw for Axial).
Plasma gas flow rate (Ar) : 10.5-15 L/min. (radial) 15 (Axial).
Auxilary gas flow rate (Ar): 1.5.
Viewing height : 5-12 mm.
Copy and reading time : 1-5 s (max. 60 s).
Copy time : 3 s (max. 100 s).

2.4. Statistical Analyses

The average is calculated by analyzing the fruits three times. Results of the research were analysed for statistical significance by analysis of variance [17].

3. Results and Discussion

The colors of apples used in experiment are green, yelow-red and red (wild). Macro and micro nutrients of three different apples are given in Table 1. While Ca is found in wild apple, it was not found in other samples. K contents of apples ranged from 8510 mg/kg (green apple) to 11942 mg/kg (yellow-red apple). The highest K contents were found in yellow-red apple and wild apple (10303 mg/kg). While Mg contents of three different apples change between 505 mg/kg (wild apple) and 734 mg/kg (wild apple), P contents ranged from 683 mg/kg (green apple) to 1145 mg/kg (yellow-red apple). In addition, S contents of samples were found between 413 mg/kg (green apple) to 556 mg/kg (yellow-red apple). As seen in Table 2, microelement contents of three different apples composed of B, Cr, Cu, Fe, Mn, Mo, Ni, Pb and Zn. Cu, Fe and Mn contents of samples were found partly high compared with other microelements. B contents of apples were found between 18.8 mg/kg (wild apple) and 21.0 mg/kg (green apple). While Cu contents of apple samples change between 4.3 mg/kg (green apple) and 5.0 mg/kg (wild apple), Fe contents ranged from 14.5 mg/kg (green apple) to 20.6 mg/kg (wild apple). Mn contents were found between 3.0 mg/kg (green apple) and 26.5 mg/kg (wild apple). Mo, Ni and Pb concentrations of apple samples were found under the <0.397 ppm. Zn contents changed between 0.15 mg/kg (green apple) and 1.96 mg/Kg (wild apple). Pb content was not found in wild apple. Generally, Cu, Fe, Mn, Mo and Zn contents of wild apple were found were found partly high compared with other apple varieties in the same tree. Obviously, the invidual trees take nutrients from the soil, even though the situation varies according to the variety. It is crucial that genetic factors are emerging during nutrient getting from soil. Each variety takes plant nutrients at different concentrations from the same root. In previous study, Calcium follows, with variation limits between 1.70 mg/100 g (‘Starkrimson’) and 8.74 mg/100g (‘Prima’) while iron content varied between 0.19 mg/100 g (‘Ionagold’) and 0.40 mg/100 g (‘Cadel’ and ‘Early Red’). The potassium content was comprised between 82.25 mg/100 g (‘Mutzu’ cultivar) and 160.85 mg/100 g (‘Florina’ cultivar), with a very significant difference, compared to the average value (112.3 mg/100 g) [1]. Iron content in apples varied between 0.19 mg/100 g in ‘Ionagold’ cultivar and 0.40 mg/100 g in ‘Cadel’ and ‘Early Red’ cultivars, with an average of 0.28 mg/100 g [1]. Average values under 0.03 mg/100 g weight were recorded for the next elements: chromium (Cr), strontium (Sr) and aluminum (Al) [1]. Henriquez et al. [18] analyzed important minerals in peel and pulp of five different varieties of apple fruit on a wet basis, and found the following concentrations: 115.1–165.1 and 68.0–107.7 (mg/100 g of K), 9.8–17.9 and 4–4.7 (mg/100 g of Ca), 21.9–25.5 and 6.3–7.3 (mg/kg of Mg), 7.0–13.0 and 1.6-6.8 (mg/kg of Na), 0.84–0.99 and 0.24–0.55 (mg/kg of Fe), 0.05–0.13 and 0.00–0.03 (mg/kg of Zn), respectively. In another study, all the apple samples analyzed contained higher amount of potassium (K) followed by calcium (Ca), magnesium (Mg) and sodium (Na). The contents of K and Ca in apple peel and pulp ranged from 695.3–980.9 and 443.6–790.1 mg/100 g DW and 35.6–72.1 and 19.8–48.9 mg/100 g DW, respectively [19]. Our results compared with literature values, they are exhibited differences. These differences (the nutritional value of apple types) can be attributed due to growing conditions, environmental factors, harvest time, storage and processing conditions.

Table 1. Macro element contents of three apple varieties (mg/Kg)

Samples	Ca	K	Mg	P	S
Green apple	0.0±0.0	8510±193	508±38	683±52	413±13
Yellow-red apple	0.0±0.0	11942±610	505±27	1145±80	556±41
Wild apple	85±4	10303±119	734±47	1000±24	523±20

*mean±standard deviation

Table 2. Micro and heavy metal contents of three apple varieties (mg/Kg)

Samples	B	Cr	Cu	Fe	Mn	Mo	Ni	Pb
Green apple	21.0±0.7*	0.034±0.004	4.3±0.4	14.5±1.7	3.0±0.0	0.215±0.021	0.345±0.060	0.169±0.018
Yellow-red apple	19.6±0.2	0.152±0.003	4.9±0.1	15.5±1.3	3.8±0.3	0.208±0.021	0.397±0.146	0.018±0.012
Wild apple	18.8±0.5	0.072±0.011	5.0±0.2	20.6±1.5	26.5±1.5	0.372±0.017	0.281±0.067	0.0±0.0

*mean±standard deviation

4. Conclusion

As a result, Cu, Fe, Mn, Mo, Zn, Ca, K and Mg contents of wild apple were found higher than those of results of other samples. In addition, P and S contents were found at the highest level in yellow-red apple sample. But, calcium was not established in Green and Yellow-red apple samples. Variation in the mineral contents among the apple types had been observed. These variations might be possibly attributed to age of the tree, agro-climatic conditions, altitude, soil type and analytical conditions.

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