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Characterization of Elemental Composition in Kiwifruit Grown in Northern Iran

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Kiwifruit (*Actinidia chinensis*) has different varieties such as Hayward, Bruno, Monty, and Abbott. These varieties are different in taste, odor, shape, and some chemical compositions. This work reports the elemental analysis of Cu, Fe, Mn, Zn, Ca, Mg, K, and Na in the different varieties of Hayward, Bruno, Monty, and Abbott grown in northern Iran. Results from elemental analysis were determined using atomic absorption and emission spectroscopy. Distributions and amounts of metals for different varieties of kiwifruit have been investigated. Results have shown that the presence of elements varied with different varieties of kiwifruit. The soils in which the kiwifruits have been cultivated also have been analyzed.

KEYWORDS: ***Actinidia chinensis*; Hayward; Monty; Bruno; Abbott; elemental analysis**

INTRODUCTION

Determination of major, minor, and trace elements in foods is necessary for proper assessment of their nutritional and/or toxicological effects on man. An initial step in this assessment is the evaluation of naturally occurring background levels in agricultural products. This work has analyzed and characterized the elemental composition of kiwifruit.

The kiwifruit (*Actinidia chinensis*) was formerly placed in the family Dilleniaceae but is now set apart in Actinidiaceae, which includes only two other genera. The kiwifruit is also known by a few little-used colloquial names such as Ichang gooseberry, monkey peach, and sheep peach.

There are several varieties of kiwifruit; the characteristics of the varieties of kiwifruit studied in this work are as follows:

Abbott fruits are oblong, of medium size, with a brownish skin and especially dense, long, soft hairs.

Bruno fruits are large, elongated cylindrical, broadest at the apex, have darker brown skin than other cultivars, and have dense, short, bristly hairs.

Hayward fruits are exceptionally large, broad-oval, with slightly flattened sides; the skin is a light greenish brown with dense, fine, silky hairs.

Monty fruits are oblong, somewhat angular, widest at the apex, of medium size, and have brownish skin with dense hairs.

Much research has been done to characterize some factors such as the nutrient abd chemical compositions and medicinal uses of kiwifruit (*1*−*5*). In this work we studied different varieties of kiwifruit to compare and characterize the elemental analysis with regaard to both the quantity and quality compositions. The Hayward variety was also used for analysis of the elements in different parts of the kiwifruit. Elemental analysis has also been performed for the soil where these varieties were cultivated. We also studied the volatile compounds in the flowers of kiwifruit, which was reported elsewhere (*6*).

MATERIALS AND METHODS

Four different varieties of kiwifruit, Monty, Abbott, Bruno, and Hayward, have been picked in the same area of northern Iran (Mazandaran). Accurate multielement analysis at trace levels depends upon the prevention of elemental contamination. All stages of sample preparation and analysis were carried out in a clean air environment. Prior to digestion or sample analysis, all glassware and plasticware were scrupulously cleaned, rinsed several times with double-distilled water, and placed in a clean air environment until dry. All kiwifruits were first cleaned and washed with water and then washed several times with double-distilled water. All of them were sliced to small pieces and dried at 60 °C. The heating, cooling, and weighing cycle is then repeated, as many times as required to achieve successive weights that do not differ from one another by >0.2−0.3 mg.

Each of the dried varieties of kiwifruits was ground to reduce particle size and then thoroughly mixed to ensure homogeneity; the method of preliminary steps for mixing solid laboratory samples has been applied in all cases. To obtain a homogeneous particle size of the grinding sample, the procedure of coning and quartering was employed with appropriate amounts of each variety of kiwifruit. A wet-ashing procedure was employed to convert the elements of interest into a susceptible form by common analytical techniques; in this work the reagent of nitric/hydrochloric acid mixtures has been used.

Soil also was collected in the same area where the kiwifruits were grown. To obtain a truly representative gross sample, a random sample of soil that weighed ∼5 kg was removed randomly from a bulk of material by the law of chance. Here also the methods of preliminary steps for mixing solid laboratory samples has been employed for all cases. Decomposition of samples has been performed by fluxes. In this case the sample in the form of a very fine powder was mixed with

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Table 1. Wavelengths and Detection Limits

element	wavelength (nm)	limit of detection (ppm)
Cu	324.8	0.018
Mn	279.5	0.009
Fe	248.3	0.044
Zn	213.9	0.004
Ca	422.7	0.080
Mg	285.2	0.051
Na	589.0	0.070
K	766.5	0.081

Table 2. Concentrations of Cu, Mn, Fe, and Zn (Parts per Million) for the Different Varieties of Kiwifruits

element	Hayward	Monty	Abbott	Bruno
Cu	9.50 ± 0.60	13.25 ± 0.85	8.20 ± 0.51	5.95 ± 0.53
Mn	20.85 ± 0.91	17.65 ± 0.75	13.40 ± 0.70	27.95 ± 0.82
Fe	58.20 ± 1.10	57.80 ± 2.10	24.40 ± 0.90	67.75 ± 2.50
Zn	10.25 ± 0.69	7.90 ± 0.20	16.45 ± 0.77	6.00 ± 0.50

Table 3. Concentrations of Na, K, Ca, and Mg (w/w %) for the Different Varieties of Kiwifruits

element	Hayward	Monty	Abbott	Bruno
Na	0.018 ± 0.007	0.015 ± 0.008	0.020 ± 0.005	0.025 ± 0.003
K	0.400 ± 0.020	0.25 ± 0.020	0.38 ± 0.050	0.320 ± 0.050
Ca	0.11 ± 0.05	0.09 ± 0.01	0.12 ± 0.05	0.09 ± 0.02
Mg	0.11 ± 0.03	0.12 ± 0.07	0.08 ± 0.03	0.07 ± 0.01

~10-fold excess of the flux; the fluxesh used in this analysis were a mixture of boric anhydride (B_2O_3) and lithium carbonate. Fusion with this reagent was performed at ~700 °C for 2 h.

Elemental analysis has been measured using a Varian atomic absorption spectrometer, Spectra AA-10. The analytical wavelengths used in this study, with corresponding detection limits, are listed in **Table 1**.

RESULTS AND DISCUSSION

The concentration of metal elements such as Cu, Mn, Fe, Zn, Na, K, Ca, and Mg in the different kiwifruit varieties Hayward, Bruno, Monty, and Abbott was investigated. The method of least-squares has been applied for all measurements to derive calibration curves; for all cases the factor of regression was >0.990.

Results from analysis of different varieties of kiwifruit for the elements copper, manganese, iron, and zinc are listed in **Table 2**. **Figure 1** visualizes the elemental analysis of different varieties of kiwifruit. As can be seen the highest concentration of copper was found in Monty, and Bruno contained the least concentration of this element. However, Bruno contains the greatest concentration of manganese and Abbott the least. The iron concentrations in the varieties Hayward, Bruno, and Monty are rather comparable; obviously, Abbott contains the least concentration of iron. Results indicate that the concentration of zinc in the Abbott variety is greater than that found in the others; the least concentration of this element is found in Bruno.

Comparison of the iron concentration with the other elements in the four varieties demonstrates that its concentration in all varieties of kiwifruits is significantly higher than that of the other elements; that is, on average, the iron concentration is ~3.5 times that of the other elements.

Results from the analysis of different varieties of kiwifruits for the elements of sodium, potassium, magnesium, and calcium are listed in **Table 3**. Mg and Ca were determined by atomic absorption and atomic emission techniques applied for measuring Na and K.

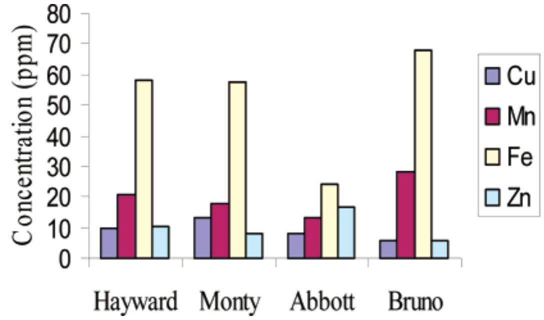

Figure 1. Elemental analysis of Cu, Mn, Fe, and Zn for different varieties of kiwifruits.

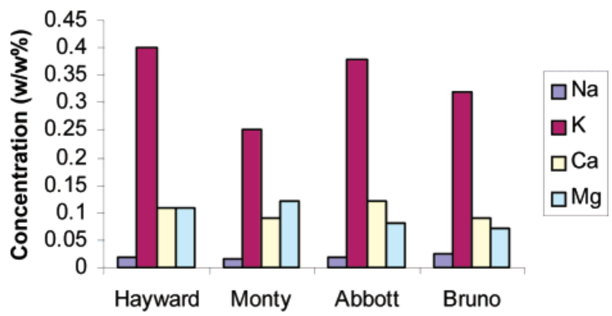

Figure 2. Elemental analysis of Na, K, Mg, and Ca for different varieties of kiwifruits.

Figure 2 presents the elemental analysis of Na, K, Ca, and Mg. It should be noted that the concentrations of these elements are given as w/w %, and therefore they are not comparable with the concentrations of the above elements (Cu, Fe, Mn, and Zn).

Comparison of the sodium concentrations in Hayward, Monty, Abbott, and Bruno reveals that the presence of sodium is different among those varieties. As can be realized, the concentration of sodium in Bruno is ~2 times more than that in Monty; nonetheless, Hayward and Abbott have rather comparable concentrations of this element. Results reveal that Monty contains the least concentration of potassium, and Hayward has the most of that one.

Figure 2 illustrates that the concentrations of calcium in the four varieties of kiwifruit are comparable to one another; Bruno and Monty have the same concentration of calcium. Analysis of magnesium in the four varieties of kiwifruits reveals that Monty has the greatest concentration, and Bruno contains the least concentration of this element; Hayward and Monty have comparable concentrations of the corresponding element.

It is interesting to compare the concentration of potassium with the other elements in this series of experiments. Results from the analysis of these elements (K, Ca, Mg, and Na) reveal that the concentration of potassium is significantly higher than that of the other elements.

The distribution of copper, manganese, iron, and zinc in different parts of the kiwifruit, that is, shell, central core, and outer pericarp, has been examined. The Hayward variety has been examined, and results of this experiment are given in **Table 4** and shown in **Figure 3**, indicates that the amounts of Cu in the shell and central core are comparable to each other but that the outer pericarp contains the least concentration of this element. However, Fe is entirely dominant in the shell of the kiwifruit, and the central core contains a only very small amount of magnesium. In contrast to the above results, the least amount of zinc exists in the shell; however, both the central core and

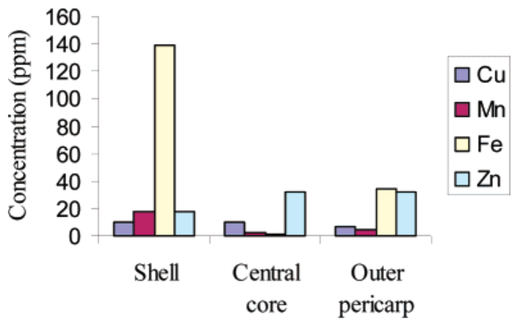

Figure 3. Elemental analysis of Cu, Mn, Fe, and Zn in different parts of kiwifruit.

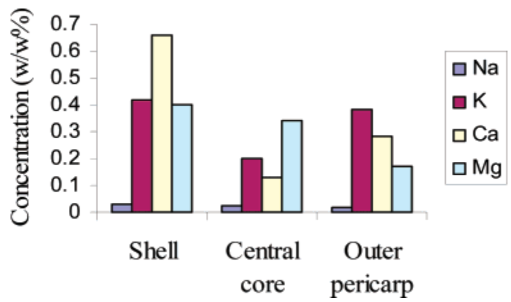

Figure 4. Elemental analysis of Na, K, Mg, and Ca in different parts of kiwifruits.

Table 4. Elemental Analysis of Cu, Mn, Fe, and Zn (Parts per Million) in Different Parts of Kiwifruit

element	shell	central core	outer pericarp
Cu	10.20 ± 0.70	9.50 ± 0.65	6.50 ± 0.53
Mn	17.80 ± 0.70	2.50 ± 0.55	3.90 ± 0.50
Fe	139.00 ± 6.20	1.30 ± 0.05	34.00 ± 0.59
Zn	18.20 ± 0.37	31.80 ± 0.69	31.60 ± 0.30

Table 5. Elemental Analysis of Na, K, Ca, and Mg (w/w %) in Different Parts of Kiwifruit

element	shell	central core	outer pericarp
Na	0.028 ± 0.004	0.026 ± 0.003	0.016 ± 0.005
K	0.42 ± 0.080	0.200 ± 0.060	0.380 ± 0.020
Ca	0.66 ± 0.07	0.13 ± 0.10	0.28 ± 0.04
Mg	0.40 ± 0.07	0.34 ± 0.03	0.17 ± 0.06

the outer pericarp have comparable concentrations of this element. Results obtained from the elemental analysis of Cu, Mn, Fe, and Zn show that the amount of iron in the shell is considerably greater than that of the other elements.

Results from the analysis of Ca, Mg, Na, and K in different parts of kiwifruit for the Hayward variety are given in **Table 5** and shown in **Figure 4**. Overall, it can be realized that the amounts of those elements are dominant in the shell. Calcium and potassium have the least concentration in the central core, whereas magnesium and sodium are found in the least concentration in the outer pericarp. It must be mentioned that the concentrations of Ca, Mg, and K are in the range of 0.1−0.7 w/w %, but the quantity of sodium is between 0.02 and 0.0.3 w/w %, which indicates the concentration of sodium is less than that of the others.

Elemental analysis of the soil collected from the areas where the different varieties of the kiwifruits were grown was also made. Results revealed that the concentrations of the elements among corresponding areas are the same and confirm that there is no relationship between concentration of the elements in the varieties of kiwifruit and corresponding elemental composition of the soil of cultivation. Consequently, it can be deduced that different concentrations of each element in different varieties of kiwifruits refer to the kind of kiwifruit.

CONCLUSION

This work reports the elemental analysis of Cu, Fe, Mn, Zn, Ca, Mg, K, and Na in different varieties of kiwifruit (Hayward, Bruno, Monty, and Abbott) grown in northern Iran. Results indicated that the distribution and amount of metals varied in the different varieties of kiwifruits. Results also showed that the amounts of elements are different in different parts of the kiwifruit. Among the elements Cu, Mn, Fe, and Zn, for all cases, Fe was found at the greatest concentration. Also, among Ca, Mg, Na, and K, K was found at the the greatest concentration. Results from analysis of the soil revealed that there is no relationship between the concentration of the elements in the varieties of kiwifruit and the corresponding elemental composition of the soil of cultivation.

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