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Mineral Characterization of Some Tunisian Apple Cultivars

Manel BOUDABOUS[1], Abessalem MRABET[1], Ali FERCHICHI[1]

Abstract: The content of major (Na, K, Ca, Mg and P) and minor elements (Fe, Cu, Zn and Mn) in apple consumed in the Tunisian arid land has been determined by using flame atomic absorption and spectrophotometer method. Significant differences were observed in the mineral contents of the apple samples. This difference between mineral contents and varieties is reported in the literature and a comparison has been carried out with diverse fruits. In generally, apples are rich in macroelements (P, Na, K, Ca and Mg) while the microelements (Cu, Zn, Fe and Mn) are in the form of traces.

Keywords: Apple cultivars, Mineral composition, Tunisia

1. Introduction

Apples are one of the most frequently consumed fruits in the world after citrus, banana and grapes. In Tunisia, commercial apple production in recent years amounted to 130 thousand tones and apples cover an area of 34 thousand hectares (FAOSTAT, 2005).

Apples constitute an important part of the human diet, as they are a source of monosaccharides, minerals, dietary fibre, and various biologically active compounds, such as vitamin C, and certain phenolic compounds which are known to act as natural antioxidants (Wu *et al*., 2006).

Many factors affect the elemental contents of fruits, for example, variety, state of ripeness, soil type, soil condition, fertilization, irrigation and weather (Tahvonen, 1993). In this study we used four apple cultivars grown in Tunisian arid land, which have not been studied before, in order to evaluate the variability of elemental composition.

2. Materials and Methods

2.1. Plant material

Four apple cultivars (Douce de Djerba, Anna, Chahla and Arbi) grown in Tunisian arid land (Djerba and Zarzis) were used for this study. The apples were harvested based on industry standards.

2.2. Mineral analysis

Plant materiel was dried at 70 ˚C. Four grams of sample (apple pulp), placed in a porcelain capsule, was calcined then by the muffle furnace at 550 ˚C/4h. After cooling, ashers were washed by 5 ml of deionised water and 1 ml of hydrochloric acid and were brought to boiling. The capsule content was filtered. The filtrate was brought to volume using deionised water to 100 ml. This solution will be used for mineral analysis.

A Shimadzu AA 6800 was used to determine the sodium, potassium, calcium, magnesium, copper, zinc, iron and manganese concentrations by atomic absorption spectrophotometry method. The element concentration was calculated according to the equation: % Na, % K, % Ca, % Mg, % Cu,% Zn % Fe and % Mn = C × V /(104 × m) × % MS, where C featured value (ppm), V extract volume (ml), m mass (g), % MS Percentage of dry material.

A Secomam spectrophotometer was used to determine the phosphorus concentration. Standard solutions of P 0, 2, 4, 8 mg/ l were prepared by diluting basic solution of P 100 mg/l, and 10 ml of each standard. The diluted extract was placed in 25 ml tubes with 10 ml of the vanadomolybdic reagent. After 10 min, the absorbencies were measured at 430 nm. Extracts were diluted as needed. P concentrations were calculated according to the formula: % P = (C × Df)/(100 × m), where C Phosphorus Concentration (mg/l), Df Dilution factor, m extract mass (g).

[1] Arid and Oases cropping laboratory, Arid Area Institute (IRA), 4119 Medenine, Tunisia.
E-mail: modoboudabous@yahoo.fr

2.3. Statistical analysis

All analysis was carried out using SPSS software 12.0 version. Data were analyzed statistically (ANOVA) using analysis of variance and means separated using Duncan's multiple range test at the $P<0.05$ level of significance. Results were expressed also in dendrogram form using the order TREE. This technique was founded on the Euclidean distance.

3. Results and Discussion

Statistical analysis show the existence of a highly significant difference ($p<0.01$) between the varieties for the character tenor of minerals (**Table 1**). In this communication, we will treat results of mineral analyses one by one.

Table 1. Elemental composition (mg/g) of selected categories of apples.

Varieties	Na	K	Ca	Mg	Cu	P	Zn	Fe	Mn
Anna	3.47^{a}	53.59^{a}	1.78^{a}	1.73^{a}	0.00^{a}	1.73^{a}	0.09^{a}	0.16^{a}	0.03^{a}
Chahla	3.43^{a}	63.22^{b}	3.80^{b}	2.47^{b}	0.02^{a}	3.46^{b}	0.08^{b}	0.36^{b}	0.05^{a}
Arbi	3.69^{a}	134.72^{c}	2.83^{c}	5.82^{c}	0.09^{b}	7.40^{c}	0.13^{c}	0.47^{c}	0.07^{b}
Douce Djerba	18.46^{b}	139.96^{c}	2.56^{d}	4.68^{d}	0.07^{b}	9.52^{d}	0.10^{d}	0.26^{d}	0.03^{c}

Different superscript in each column indicates the significant differences in the mean at $P<0.05$.

3.1. Potassium

Results show that the four varieties studied are very rich in this mineral element. Potassium (K) was the most predominant element present in all categories of apples. Indeed, its content varies from 53.59 "Anna" to 139.96 mg/100 g "Douce de Djerba".

Similar results were found by Eisele and Drake (2005), during their tests to identify the mineral composition of 175 varieties of apples trade from 12 countries and several regions of the United States. Indeed, the potassium content in all varieties is very high and peaked at 2712.3 ppm, a content that is very high in comparison with our varieties (21.43 to 55.98 ppm). In contrast, Emaga *et al*. (2007) showed that banana is characterized by potassium levels ranging from 5.52 to 6.35 mg/100 g, relatively low in comparison with our results.

Ercisli and Orhan (2007) demonstrated that potassium is the predominant element founded in three varieties of mulberry studied. Indeed, the levels of K vary from 834 mg/100 g (*Morus rubra*) to 1668 mg/100 g (*Morus alba*). In the same case, Vasantha and Clegg (2007) have shown that potassium is the most dominant mineral in ten varieties of grapes analyzed.

Potassium promotes the growth of the fruit; in general, a high K content of fruit is correlated with an increase in fruit size. In contrast to nitrogen, potassium has a positive effect on the formation of organic acids and accelerates the development of color (Huguet *et al.*, 1971).

3.2. Sodium

The variation of the sodium content at the various studied varieties is shown in Table 1. Values oscillate between a maximum recorded at the Douce de Djerba variety (18.46 mg/100 g) and a minimum at the Chahla variety 3.43 mg/100 g. Results from this study indicates these varieties are characterized by low levels of sodium compared with the results given by Eisele and Drake (2005) which refer to levels between 0.5 and 73.4 ppm with an average of 11.8 ppm.

3.3. Calcium

Calcium is an essential element to the cohesion of the cells. It has a role in the conservation of fruit. Present in sufficient quantity, it slows the ripening process by slowing breathing and loss of firmness (Fallahi *et al.*, 1985). It participates in maintaining cellular integrity stiffen its action on membranes and also in maintaining protein synthesis (Hopfinger and Poovaiah, 1979).

Table 1 shows that the variety Chahla presents the highest level of calcium (3.8 mg/100 g), while Anna presents the lowest content (1.78 mg/100 g). In generally, we can say that our varieties are not rich in this element, values range from 0.71 to 1.52 ppm with an average of 1.09 ppm, in comparison with the findings of Eisele and Drake (2005) who found values which range from 18.7 to 80.3 ppm with an average of 41.9 ppm.

3.4. Magnesium

High levels of magnesium in fruit results in an increase in tissue firmness and total acidity (Huguet *et al*., 1971; Papp and Aziz, 1989). This significantly influences photosynthesis, on the one hand, because it enters the composition of chlorophylls and on the other hand because it acts as cofactor on a certain number of enzymes and in particular on the key enzymes of the cycle of pentose phosphates, controlling the photosynthetic CO_2 fixation.

For the different varieties studied, magnesium content varies between a minimum of 1.73 mg/100 g registered with Anna variety and a maximum of 5.82 mg/100 g in Arbi. It's the Douce de Djerba which contains the most important value of Mg (Table 1).

Hopfinger *et al*. (1984) highlighted the role of magnesium and calcium on the enzymatic browning of apple tree. Indeed, these authors showed that the enzymatic tanning due to the polyphenoloxydase, was stimulated by the addition from 0.8 to 10 mM of $MgCl_2$ whereas the addition of $CaCl_2$ to the same concentration has an opposite effect. This leads to the supposition that the enzymatic tanning of apple is stimulated by an imbalance in the ratio Mg/Ca of tissue.

3.5. Phosphorus

The phosphorus has a beneficial effect on root growth and fruit set. Phosphorus fertilization allows an increase in the circumference of trunks and productivity of trees.

The decline in P content of fruits is correlated with an increase in fruit size and an increase of total acidity (Travers, 2004).

For the studied varieties, Table 1 shows that the phosphorus concentrations oscillate from 1.73 mg/100 g (Anna) and 9.52 mg/100 g (Douce de Djerba).

Compared to other fruits such as blackberries or dates whose concentrations respectively range from 226 to 247 mg/100 g (Ercisli and Orhan, 2007) and from 57.4 to 91.6 mg/100 g (Mrabet, 2005) we can say that apple is classified as one of the fruits which are not very rich in phosphorus.

3.6. Microelements

The concentrations of Cu, Fe, Mn and Zn are very low and at times at on trace levels. Despite this low level, the difference between the varieties is significant. This variability may be due to the fact that varieties are not analyzed from the same source and therefore they were not grown under the same soil and environmental conditions. This assumption is advanced by Hakala *et al*. (2003) during their tests to identify the chemical composition of mulberry and Youssef *et al*. (1982) to identify the date composition.

4. Comparison of the studied varieties according to their mineral content

Results of apple mineral composition permit to discuss two groups (**Fig. 1**).

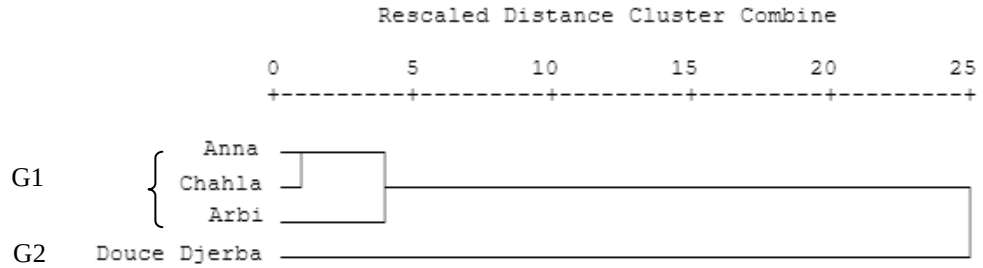

Fig. 1. Dendrogram obtained in the basis of mineral content of the different apple cultivars.

Group 1: Contains the majority of the varieties (Anna, Chahla and Arbi) which are characterized by:

- A mean content of sodium (3.43 to 3.69 mg/g);
- A high content of calcium (1.78 to 3.8 mg/g);
- A high content of magnesium (1.73 to 5.82).

Group 2: This group contains only one variety (Douce de Djerba) which is characterized by:

- A high content of sodium (18.46 mg/g);
- A high content of potassium (139.69 mg/g);
- A high content of phosphorus 9.52 mg/g).

5. Conclusions

The mineral composition results showed that our varieties are relatively rich in macroelements (P, Na, K, Ca and Mg) whereas the microelements (Cu, Zn, Fe and Mn) are in the form of trace. Potassium was the most abundant mineral found in all apple categories. Calcium was significantly higher in Chahla than in the other apples while magnesium was higher in Arbi variety. It is quite clear that the Douce de Djerba variety makes the difference as long as it contains the most important content of sodium, potassium, and phosphorus.

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