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Full Length Research Paper

HPLC determination of sugars and atomic absorption analysis of mineral salts in fresh figs of Tunisian cultivars

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The major nutrient components in fig (*Ficus carica* L., *Moraceae*) are sugars and mineral elements, mainly starch, followed by glucose, fructose, K, Ca, Mg, Na and Zn. These nutrients composition are some of the most important elements in the assessment to the commercial quality of fig fruits. In this study, we assessed glucose and fructose contents in different Tunisian fresh fig cultivars using high performance liquid chromatography (HPLC) as well as mineral salts using atomic absorption spectrophotometeric methods. The values of glucose and fructose range from 1.216 – 6.133 and 1.916-4.658 g/100 g of fresh matter, respectively. All cultivars were rich in mineral elements, especially in Ca and Mg.

Key words: Tunisia, fresh fig cultivars, glucose, fructose, mineral elements, HPLC, atomic absorption spectrophotometry.

INTRODUCTION

The fig fruits (*F. carica* L., *Moraceae*) are very rich in sugars and mineral salts (Aksoy, 1987; Ozer and Derici, 1998; Colelli, 1995; Vinson, 1999). Fructose and glucose are the major sugars in figs (Melgarejo et al., 2003; Genna et al., 2005). The important Mineral elements are K, Ca, Mg, Na and Zn (Bolin et al., 1980; Vidaud et al., 1997; Aksoy, 1998). Those nutrients compositions are very important for the assessment of the commercial quality of fresh and dried figs (Genna et al., 2005). Fig fruits are very nourishing food and used in industrial product (Guesmi et al., 2006).

A comparison of the mineral elements contents of figs with that of other fruits indicates that figs have calcium contents higher than apples, dates, grapes, strawberries fruits, and contain more potassium than apples and dates fruits (Vinson, 1999). Ozer and Derici (1998) have also analysed the contents of fresh figs in Turkey varieties using atomic absorption spectrophotometeric methods to determinate mineral salts. Melgarejo et al. (2003) studied sugars in fresh figs from different Spanish varieties using high performance liquid chromatographic (HPLC) techniques and obtained values of glucose from 10.66 to 15.89 g/100 g fresh matter, and fructose contents from 4.33 to 6.28 g/ 100 g fresh matter.

This research analyses the sugars and mineral elements of fresh figs harvested from fourteen Tunisian local cultivars. Particularly, the objectives of the current study are to identify and quantify those nutrients composite.

MATERIALS AND METHODS

Plant material

Bir Amir and Beni Keddache fig producing areas were chosen from two governments in southern Tunisia: Médenine, Tataouine (Table 1). For this work, fourteen Tunisian local fig cultivars listed in Table 1 were used. The number of trees of each cultivars utilized in this investigation depended on the greater or lesser abundance of cultivars. In the fig ripening season (summer 2004), 20 figs were gathered early in the morning from each tree were taken at random, and plant material was placed in polyethylene bags and frozen in our laboratory.

Determination of sugars using high performance liquid chromatography

The methods described by Erosy et al. (2003°), Miguez Bernardez

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Table 1. Names, labels and origins of Tunisian fig cultivars.

Accession name	Label	Geographic origin
Bayoudhi	BTH	Beni Kheddache
Bither	BYD	Bir Amir
Jemaâoui	JMA	Beni Kheddache
Magouli	MAG	Bir Amir
Makhbech	MKH	Bir Amir
Minouri	MNR	Bir Amir
Rogabi	RGB	Beni Kheddache
Romani	ROM	Bir Amir
Safouri	SAF	Beni Kheddache
Sawoudi	SWD	Bir Amir
Tayouri Akhdhar	TAD	Bir Amir
Tayouri Ahmar	TAH	Beni Kheddache
Wedlani	WDL	Beni Kheddache
Zidi	ZID	Bir Amir

et al. (2004) and Piga et al. (2005) were used with some modifications. Sugars were determined from 12 g of fresh fruits figs in the combined extracts using high-performance liquid chromatography: HPLC (Knauer type model Wellchrom, Germany) with a universal evaporative lights scattering detector. In the mobile phase we used a solution of acetonitrile at 80% (v/v), previously filtered and degasified. The column used was Eurospher 100 NH2. The detector was taken by a refractometer (RI Detectors K-2301). Working conditions were: flow rate of 1.0 ml/min, ambient temperature and 2 Mpa pressure. The quantity and quality of glucose and fructose in all samples were determined. Standard solutions of glucose and fructose (purchased from Carlo Erba, French) were injected into the column. With those two standard solutions, calibration lines for each one of the sugars were made, which were later used for assessing the concentrations corresponding to the different peaks in the chromatograms. Areas of peaks were determined by the Euro chrome 2000 software.

Extraction mineral elements using atomic absorption spectrophotometer

Mineral elements were extracted and analysed by Atomic Absorption spectrophotometry according to the methods described by Cucu (1998), Ozer et al. (1998) and Erosy et al. (2003b). 1 g of fresh fig fruits were weighed and dried at 105 for 24 h, before placing the dry matter in a porcelain cup and charring it in a muffle oven at 550°C for 4 h. After cooling, 5 ml hydrochloric acid solution at 20% (v/v) was added. Then it was boiled and the content was filtered into a 100 ml flask with ionised water. Mineral elements were determinate by atomic absorption spectrometry (SHIMADZU AA 6800, Italy).

Statistical methods

For the statistical analysis of our sampling we used SPSS12.0. Comparisons were carried out at 95% confidence by application of analysis of variance (ANOVA) and Duncan Test, which establishes a comparison of sugars and mineral elements contents means within fig cultivars. Multivariate analysis was studied on fig cultivars groups.

RESULTS AND DISCUSSION

Descriptive analysis

The analyses of nutrient elements with the exception of K in fig cultivars show that variation coefficients higher than 20% (Table 2). Glucose and fructose contents were 3.49 and 2.54 g/100 g fresh matter, respectively. K and Ca contents were 739.75 and 295.86 mg/100 g dry matter, respectively (Table 2).

Variance analysis and means comparison

Mean values of sugars and mineral salts are reported in Table 3. A high variability within cultivars for all analysed parameters and significant difference was observed. The values obtained for glucose ranged from 1.216 to 6.133 g/100 g fresh matter (Table 3). These results were lower than those obtained by Turkish investigators (Melgarejo et al., 2003). *Gobernador* variety showed the lowest glucose content, while *Tio Antonio* and *Calar* were the sweetest varieties with 15.89 and 13.41 g/100 g fresh matter, respectively. The values obtained for fructose were low (Table 3), ranging from 1.916 to 4.658 g/100 g fresh matter. These were similar to the values obtained by Melgarejo et al. (2003).

The mean values of fruit mineral salt of fresh fig cultivars were showed in Table 3. All mineral elements of our cultivars maintained the reference values (Aksoy et al., 1987; Ozer and Derici, 1998), whereas Ca and Mg have higher values. Those authors determined the amount of mineral elements in Turkish fruits figs cultivars as 680 - 1050 K, 167 - 333 Ca, 11 - 107 Mg, 20 - 67 Na and 0.8 - 2.0 Zn mg/100 g dry matter. These differences may be due to various factors, i.e., different origin of figs cultivars, plants nutrients, differences in ripening, etc.

Correlation Variables

The relationship was found within all nutrients elements (Table 4). We showed a significant correlation within Glucose-Ca, Mg-Ca, Na-sugars and glucose-fructose. Ca was negatively correlated with glucose, and Ca and Na has a negative correlation with glucose and fructose (Table 4).

Multivariate analysis

Cluster analysis on nutrients elements of fresh figs cultivars showed tow groups G1: SWD, TAH, SAF, ZID and MNR, G2: BTH, ROM, BYD, JMA, RGB and TAD. On the other hand, three cultivars were isolated from the other; I1: MAG, I2: MKH and I3: WDL. The first group can be considered very distinct of the other cultivars. Those cultivars revealed a very highly contents of K and low quantity

Table 2. Means, standard deviation and variation coefficient of sugars (g/100 g fresh matter) and mineral elements (mg/100 g dry matter) of Tunisian fresh fig cultivars.

Means*	Glucose	Fructose	K	Ca	Mg	Na	Zn
	3.49	2.54	739.75	295.86	71.64	28.95	1.25
Standard deviation	1.18	0.76	103.89	88.36	15.14	10.68	00.42
Variation coefficient	33.81	29.92	14.04	29.86	21.13	36.89	33.6

*Means of 3 assays

Table 3. Means of sugars (g/100 g fresh matter) and mineral elements contents (mg/100 g dry matter) of Tunisian fresh fig cultivars.

Cultivars	Glucose	Fructose	K	Ca	Mg	Na	Zn
BYD	4.662	3.525	647.26	304.57	78.78	26.65	**2.08**
BTH	3.587	2.204	721.64	200.63	56.35	12.33	1.07
JMA	3.375	2.450	663.5	312.86	78.59	19.71	1.09
MAG	**6.133**	**4.658**	834.35	**151.76**	**51.69**	**19.7**	1.32
MKH	3.604	2.854	**541.27**	254.2	69.08	32.32	2.03
MNR	3.325	2.320	791.43	**448.07**	95.07	28.07	1.19
RGB	3.214	2.41	748.88	319.27	65.83	**57.52**	0.87
ROM	3.525	1.983	676.71	228.08	94.74	26.3	1.16
SAF	1.750	2.130	802.62	357.23	64.59	35.04	0.94
SWD	3.125	2.525	870.52	392.5	82.15	37.38	1.43
TAD	3.683	2.850	743.4	278.97	60.95	21.73	**0.77**
TAH	**1.216**	**1.916**	**875.95**	401.03	**91.22**	33.84	1.11
WDL	3.633	2.908	596.82	169.19	52.44	29.18	**0.72**
ZID	3.845	3.220	842.22	323.75	61.5	25.63	1.72
Signification degree	**	**	**	**	**	**	**

**Highly signification difference at $P < 0.05$
Highlighted values are minimum and maximum values.

Table 4. Correlation coefficients of nutrient elements in Tunisian fig cultivars.

K	1							
Ca	0.49	1						
P	0.48	0.45	1					
Mg	0.13	**0.66**	0.25	1				
Na	0.13	0.41	-0.12	0.17	1			
Zn	-0.18	0.08	0.30	0.17	-0.09	1		
Glucose	-0.20	**-0.57**	-0.02	-0.31	**-0.69**	0.41	1	
Fructose	-0.07	-0.47	0.14	-0.33	**-0.54**	0.46	**0.92**	1
	K	**Ca**	**P**	**Mg**	**Na**	**Zn**	**Glucose**	**Fructose**

Highlighted values: Significant level at alpha 5% level.

of Glucose. The second group included cultivars, witch were characterized by an elevated percentage of Mg and lowed K contents. The cultivars MAG was very rich in glucose, fructose, Ca, Mg and Na nutrient elements. But

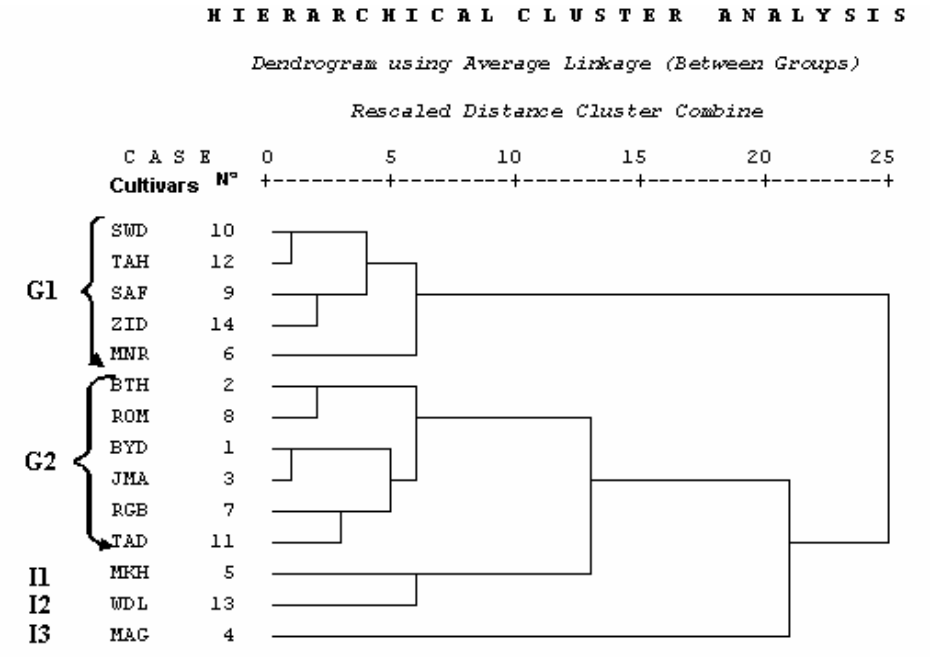

Figure 1. Nutrient elements dendrogram of Tunisian fig cultivars based in Dice similarity index. G1, First cultivars group; G2, second cultivars groups; I1, Individual 1; I2, Individual 2; and I3, Individual 3.

MKH and WDL cultivars had lowest content of K and Zn, respectively (Table 3 and Figure 1).

Conclusion

The methods used for determination of sugars and mineral elements, HPLC and atomic absorption spectrophotometric, respectively, were used to measure the contents of glucose, fructose, K, Ca, Mg, Na and Zn in fourteen Tunisian fig cultivars. In general, all the studied cultivars were rich in those nutrients elements. The extraction procedure with the HPLC analysis and atomic absorption spectrometry are in progress at our lab to check for vitamins contents in fresh fig cultivars, determination of micro mineral elements and analysis of some other cultivars from different areas in Tunisia.

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