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Changes in Sugar Contents of Fig Fruit (*Ficus carica* l. Cv. Bursa Siyahı) During Development

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Abstract: This experiment was carried out in Akdeniz University, Agricultural Faculty, Horticulturae Department and samples were taken from 10 years old fig (***Ficus carica*** L. cv. Bursa Siyahı) trees. The aim of this study was to determine the sugar contents of fig fruits, which were harvested at different growing stages, by High-Performance Liquid Chromatography technic. Changes in major and minor sugars of fruits were investigated during different fruit development stages. Amount of fructose and galactose were found to be the highest and predominant in all growing stages, while glucose and sucrose followed them, respectively. Sucrose concentration in the first and third fruit growing stages was found to be higher than second stage. Ribose, xylose, arabinose, maltose and lactose were also determined in trace amounts.

Keywords: Fig, Ficus carica L., Bursa Siyahı, sugars, fruit development, High Performance Liquid Chromatography (HPLC)

İncir (*Ficus carica* L. Bursa siyahı) Meyvelerinin Meyve Gelişimi Boyunca Şeker İçeriklerindeki Değişimler

Özet: Bu çalışma Akdeniz Üniversitesi Ziraat Fakültesi, Bahçe Bitkileri Bölümünde yapılmış olup, örnekler 10 yaşlı incir *(Ficus carica* L. cv. Bursa Siyahı) ağaçlarından alınmıştır. Çalışmanın amacı, farklı gelişme dönemlerinde hasat edilen incir meyvelerinin şeker içeriklerinin Yüksek Performanslı Sıvı Kromatografisi (HPLC) tekniği ile belirlemektir. Farklı meyve gelişme dönemleri boyunca meyvelerdeki majör ve minor şekerlerdeki değişimler saptanmıştır. Tüm gelişme dönemlerinde fruktoz ve galaktoz miktarları baskın bulunurken, sırasıyla glukoz ve sakkaroz bunları izlemiştir. Sakkarozun aktivitesi ilk ve üçüncü büyüme dönemlerinde ikinci döneme kıyasla daha etkin bulunmuştur. Şekerlerden riboz, ksiloz, arabinoz, maltoz ve laktoz ise eser miktarlarda tespit edilmişlerdir.

Anahtar kelimeler: İncir, Ficus carica L., Bursa Siyahı, şekerler, meyve gelişmesi, Yüksek Performanslı Sıvı Kromatografisi (HPLC)

Introduction

Generally sugars are one of the biochemical components of fruit and amount of sugars directly influence the fruit quality. Therefore, it is important to elucidate the enzymes of sugar metabolism.

Soluble sugar content is an important factor in evaluating fruit quality, and various attempts have been made to increase sugar content, which is influenced by many factors during the fruit development. Thus, studies on sugar accumulation in fruit will provide fundamental information about fruit quality (Hirai, 1980). High-Pressure Liquid Chromatography (HPLC) has been applied to carbohydrate analysis in foods for several years and has become the method of choice for most analyses, replacing Gas Liquid Chromatography (GLC) procedures, because of speed and simplicity of sample preparation (Folkes *et al.*, 1988).

Sugar content and its fractions are known to be among the significant quality attributes. In most cases, the fruits are

classified according to the dominant sugar (Hakerlerler *et al.*, 1997). Sweetness is an important indicator of fruit quality and highly correlated with ripeness in most fruit. Ripen fruits have higher sugar contents compare to the immature ones (Cho *et al.,* 1993).

It is well known fact that sugar is one of the main ingredients of fruits. Sugar content and its quantity according to fruit maturity stage can be changed, species climate and soil conditions (Whiting, 1970; Cemeroğlu *e*t al., 1986).

This study was conducted on Bursa Siyahı fig cultivar, which has a great importance on fresh fig production and export in Mediterranean and Marmara regions of Turkey. The aim of this study was to determine sugar contents of fruits which were harvested different maturation stages using HPLC technique. Studies on sugar accumulation in Bursa Siyahı fruit will provide fundamental information about fruit quality.

Material and Method

Material

Experimental fruits were taken 10 years of trees Bursa Siyahı cultivar which is a late cultivar for fresh consumption. Fruits were taken in three developmental stages depending on the fruit growth and maturity. Fruits were harvested at first growth period (green small; premature), second growing period (green-big) and third growing period (dark purple-harvest in maturity). In these growing stages, fruit diameters were 16.82, 31.91 and 47.57 mm, respectively.

Method

Standard sugar solutions

The sugar concentration in the fruit was measured following the procedure of Camara *et al.* (1996) and Topuz (1998). Flow diagram outlining preparation of the extracts used in sugar analysis is presented in Figure 1. Standard solutions at 1 mg.ml^{-1} of sucrose, glucose, fructose, galactose, arabinose, xylose, ribose, maltose and lactose (Car-11, Sigma) were used for calibration. They were dissolved in distilled water; acetonitrile was added to each solution to obtain a composition similar to that of the mobile phase (75:25 volume ratio). Daily prepared standard solution were filtered through a Milipore FH (0.45 µm) membrane. The obtained sample chromatograms were again compared to internal standards.

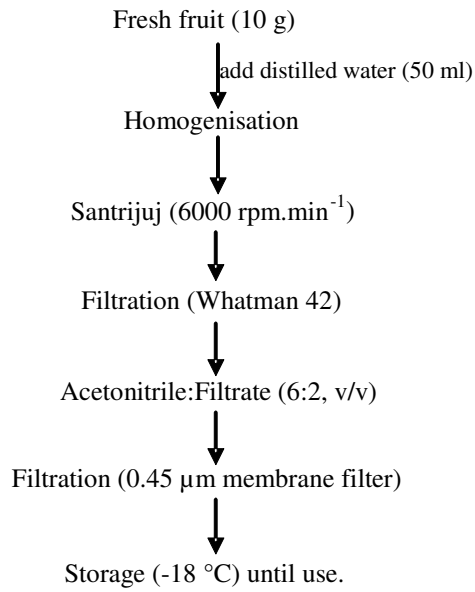

Figure 1. Flow diagram outlining preparation of the extracts used in sugar analyses

Apparatus

The sugar concentration was determined quantitatively by Varian 9010 HPLC Solvent Delivery System, Varian Marathon Autosampler and Varian Star 9040 Refractive Index (RI) Detector.

Chromatographic conditions

- Column: Supelco (300mmx4.1 mm I.D.)
- Column temperature: Room temperature (18-22 °C)
- Mobile phase: Acetonitrile:distilled water (75:25)
- Flow rate: 1.8 ml.min^{-1}
- Detector: RI, 30 °C
- Injection concentrate: 20 µl
- Duration of analysis: 15 min

Soluble solid content

Soluble solid contents (SSC), expressed as %, and were measured by a hand refractometer after fruits samples homogenised and filtered.

Statistical Analysis

Analysis of Variance was performed using the Statistical Analysis System (SAS Institute, 1987).

Results and Discussion

Sugar contents

Sugar fractions determined at the end of the sugar analyses were ribose, xylose, arabinose, fructose, glucose, galactose, sucrose, maltose and lactose (Table 1). Amount of these sugar fractions showed variation during different stage of fruit growth. According to the results, amount of all sugar contents, except maltose and lactose, increased as the fruits get more ripe. Yoshioka (1995) reported that the sugar rose sharply coincident with purple colour development on the skin surface. During ripening (from green to the full-ripe stages), the fructose, galactose, glucose and sucrose concentrations increased from 2.77 to 7.46 %, 1.92 to 7.86 %, 0.09 to 2.30 %, and from 0.97 to 1.25 %, respectively. Analysis of the fruits showed that fructose and galactose were the principal sugars, fol1owed by glucose and sucrose in all growing stages, while other sugar contents were present in trace amounts. Amount of simple sugars in fruits, such as fructose and sucrose were detected highest at the early stage of fruit growth and afterwards it reduced in the second growth stage. On the other hand, when the fruit was mature there was a rapid increase on amount of these sugar concentrations (Table 1 and Figure 2). Results of present study are in agreement with Gürcan *et al.* (1996) who also used HPLC technique to state that amount of fructose was higher than glucose and amount of sucrose was very low in Bursa Siyahı cultivar. In another study which was conducted by using GC method with seven fig clones and three fig cultivars, including Bursa Siyahı cultivar, amount of fructose was found to be the highest in all cultivars and clones, which was followed by glucose (Hakerlerler *et al*., 1998). But they were not able to detect any sucrose in their experiment and that could be due to using different analysis method. On the other hand, as it was indicated by Whiting (1970) and Cemeroğlu e*t al.* (1986) reported that sugar content and its quantity changed in fruits may depend upon the variety, fruit maturity stages, climate and soil conditions.

Total sugars

Results on the average content of total sugars of fig fruits are given in Table 1. Means values of total sugars showed large differences during the growing progress. As it can be seen in Table 1, the average total sugar contents ranged between 6.46 and 20.23 %. In fruits, total sugar concentrations were lowest at the beginning of fruiting and the highest at the harvest time. Total sugar content increased throughout the fruit development and maturation. The results of present study are in agreement with Gürcan e*t al.* (1996) who also used HPLC technique and Bursa Siyahı cultivar, who reported that amount of total sugar contents were 10.55 % in full-ripe. Data related to variations in fruits total sugar content throughout the fruit development are presented in Figure 2. The total sugar contents were lowest in young fruit and increased sharply during the maturation. (Figure 2). Fruit maturation is result of the development of fruit colour induced the sugar accumulation.

Soluble solid content

Data are graphically presented in Figure 2, on variations in fruit soluble solid content (SSC) throughout the fruit development. As could be seen in Table 1 and Figure 2, soluble solid content increased with increasing fruit size. In fruits, SSC during the growing period varied between 7.40 and 8.60 %. The content of soluble solid was 7.40 % in second growing period the lowest content. SSC tended to increase during ripening.

Table 1. Sugar profile of fig fruits during the maturation stages.[1]

Constituents	Growing Stages		
	First	Second	Third
Ribose (%)	0.0180 ± 0.00	0.1274 ± 0.00	0.2618 ± 0.01
Xylose (%)	0.1907 ± 0.02	0.2918 ± 0.01	0.6149 ± 0.05
Arabinose (%)	0.1408 ± 0.01	0.1620 ± 0.01	0.3448 ± 0.04
Fructose (%)	2.7726 ± 0.09	2.2578 ± 0.19	7.4630 ± 0.67
D+Glucose (%)	0.0903 ± 0.01	0.3574 ± 0.03	2.3027 ± 0.28
Galactose (%)	1.9162 ± 0.10	2.1096 ± 0.15	7.8640 ± 0.74
Sucrose (%)	0.9688 ± 0.07	0.4240 ± 0.06	1.2459 ± 0.06
Maltose (%)	0.0320 ± 0.00	0.0632 ± 0.01	0.0118 ± 0.00
Lactose (%)	0.3314 ± 0.02	0.0458 ± 0.00	0.1173 ± 0.01
Fructose/Glucose (%)	31.1443 ± 3.24	6.3932 ± 0.63	3.3449 ± 0.55
Total Sugar (%)	6.4623 ± 0.30	5.8389 ± 0.25	20.2261 ± 1.32
Soluble solid content (%)	10.4667 ± 0.07	7.4000 ± 0.00	18.6000 ± 0.00

[1]Data are shown the means ± SE of three replications.

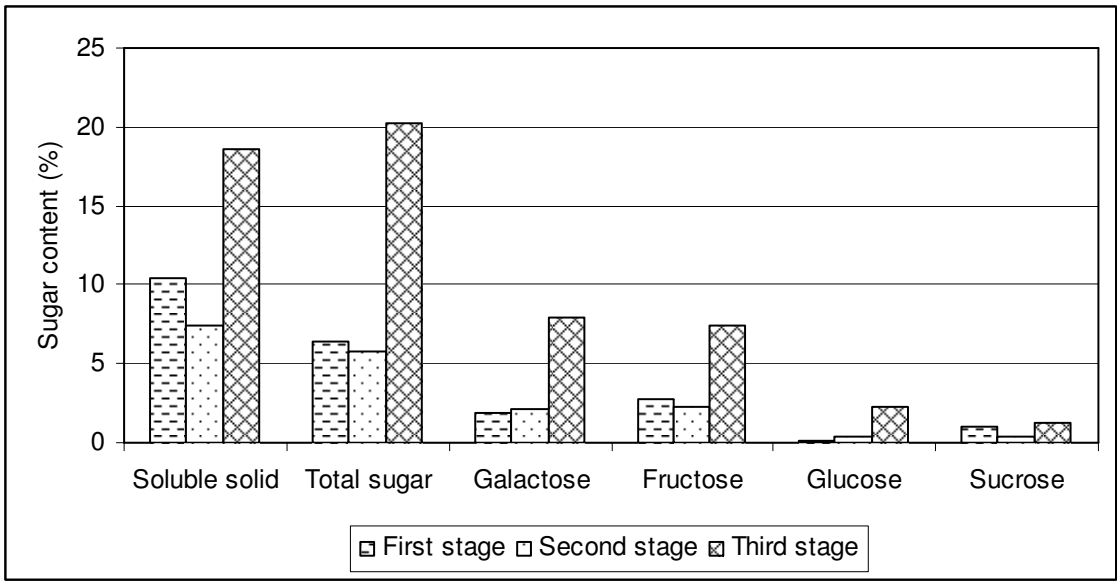

Figure 2. Sugar content of fig fruits in different growing periods.

Amount of SSC started to increase from second growing period and reached to maximum in maturity. These results were in agreement with the findings of Kaynaş *et al.* (1998) who reported that SSC was 17.70 % in Bursa Siyahı fruits at maturity. Having a highest in maturity SSC can be due to low temperature which occurs in autumn which is coincident with harvest time of late fig cultivar Bursa Siyahı.

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