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Sugar profiles of the pods of cultivated and wild types of carob bean (*Ceratonia siliqua* L.) in Turkey

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Abstract

The aim of the study was to determine the main sugar profiles of the pods, without the seeds, of cultivated and wild types of the carob bean grown in the Mediterranean and Aegean basin of Turkey. The most abundant sugar in the pods was sucrose with smaller amounts of glucose and fructose. The pods of cultivated varieties had a higher ($p < 0.05$) total sugar concentration of 531 ± 93 g/kg dry weight than the wild type selections which had 437 ± 77 g/kg. However, this difference was due to the greater concentration of sucrose in the cultivated varieties which did not differ from the wild types in their concentrations of fructose or glucose. The ratios of individual sugars to total sugars in the pods were similar in both varieties. There is a need to identify extreme wild types, including high seeds and low pod, and cultivated types, containing low seeds and high pod, rich in sugar for an exhaustive picture of the sugar profiles of the varieties.

Keywords: Carob bean; Carob sugars; Carob pod; Carob seed

1. Introduction

Carob (*Ceratonia siliqua* L.), is a tree that has been widely grown in the Mediterranean region for a long time. It belongs to the *Caesalpinaceae* sub family of the family Leguminoseae (syn Fabaceae) (Battle & Tous, 1997; Yousif & Alghzawi, 2000). The production of carob pod in the world is estimated at about 315,000 tonnes per year and the main producers and exporters are Spain (42%), Italy (16%), Portugal (10%), Morocco (8%), Greece (7%), Cyprus (6%) and Turkey (5%) (Fletcher, 1997). The total area is approximately 200,000 hectares and the yield depends on cultivar, region and cultural practices (Makris & Kefalas, 2004). Turkey is located within the region where the plant originated and has mainly two types; ''cultivated'' and ''wild'' (Karkacier, Artik, & Certel, 1995). Carob production in Turkey is about 13,500 tonnes per year from 354,000 trees, of which 306,000 are bearing and 48,000 are non-bearing (Anonymous, 2002). Carob is a drought-resistant, perennial leguminous tree, with beanlike fruit (Owen et al., 2003) and requires little maintenance (Fletcher, 1997). It is also a high value cash crop and a valuable resource for reforestation to manage erosion in marginal lands (Correia & Martins-Loucao, 1995, 2005). Several products are produced from the seed and pod (Fletcher, 1997), and the economic importance of the crop results from the use, by industry, of locust bean gum that is obtained from the seeds (Custódio, Carneiro, & Romano, 2005). The gum is a galactomannan, a valuable natural food additive for products such as ice cream, sweets and soups. It is also used in the textile and cosmetics industries (Santos, Rodrigus, & Teixeira, 2005). The pod of the carob fruit has long been used as a feed for livestock and in human nutrition, including sweets, biscuits and processed drinks, because of its high sugar content (Davies, Orphanos, & Papaconstantinou, 1971; Khair, El-Shatnawi, & Ereifej, 2001).

The mature fresh fruit is made up of about 90% of pod (known as kibble) and 10% of seed (Fletcher, 1997). The

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kibble is 40–60% sugar, predominantly sucrose, which constitutes about 30%. It is low in protein (3–4%) and lipids (0.4–0.8%) (Marakis, 1996; Santos et al., 2005; Silanikove et al., in press; Yousif & Alghzawi, 2000). The pods also contain a high amount of dietary fibre and polyphenols (Marakis, 1996). The fruit or bean of the wild types contains relatively larger proportions of seeds than do those of the cultivated types, and the quality of the bean depends on seed yield (Battle & Tous, 1997). On the other hand, the firms which produce carob syrup or carob powder prefer cultivated types. The pods of cultivated types are high in sugar and are used extensively as a raw material for the production of syrups (Roseiro, Girio, & Collaco, 1991) and, consequently, firms that produce carob syrup or carob powder, prefer cultivated types. The chemical composition of carob pods, on the other hand, differs widely according to carob species and climate (Battle & Tous, 1997; Owen et al., 2003). Sugars contained in the pods are almost entirely sucrose, fructose and glucose, but their relative proportions are variable (Karkacier & Artik, 1995; Kumazawa et al., 2002).

The aim of this study was to determine whether the pods of the cultivated and wild types, grown in the Mediterranean and Aegean basin of Turkey, differed in the profiles of the three main sugars.

2. Materials and methods

2.1. Materials

Samples of carob beans were harvested from trees growing along the coastline of the eastern to western Mediterranean region of Turkey during late August, 2002. Samples were taken from 22 trees of cultivated and 31 trees of wild types. Some physical and pomological features of the samples due presented in Table 1. Each sample contained 15–20 beans. The beans were then cut to separate the pod from the seeds. The pods were used for measurement of sugar concentrations after drying to constant weight in a vacuum drier at 70 °C.

2.2. Sample preparation

For sugar extraction, 10 g of ground, dried pods were mixed with 40 ml of water, homogenized using an Ultraturrax macerator at 24,000 rpm and centrifuged at 6000 rpm for 30 min at ambient temperature. The supernatant was filtered through Whatman 42 filter paper (Whatman, Kent, UK) and the filtrate was passed through a Sep-Pak C18 cartridge (Alltech, Deerfield, IL) and 2.5 ml of filtrate mixed with 7.5 ml of acetonitrile (J.T. Baker, the Netherlands). The mixture was filtered through a 0.45 μm membrane (Alltech, Deerfield, IL) and analysed as described elsewhere (Karkacier, Erbas, Uslu, & Aksu, 2003).

2.3. Chromatographic system

The chromatographic system used was a Varian HPLC equipped with a model 9010 solvent delivery system and a Marathon autosampler with 20 μl loop (Varian, Harbour City, CA). A Varian 9010 RI detector was used for detection. The column was an Alltech amino-bonded column (10 μm, 300 × 4.1 mm i.d.) and the mobile phase was a mixture of acetonitrile and water (75:25) for isocratic elution. The sugar standards were obtained from Sigma (St. Louis, MO).

2.4. Data analysis

Data were subjected to one-way analysis of variance using SAS software.

3. Results and discussion

Both cultivated and wild types were remarkably rich in sugar (Table 2) although there was considerable variation in the different sugars in both populations (Fig. 1). In terms of mean values of sugars, sucrose and total sugar contents of both types were found to differ significantly ($p < 0.05$). However, there were a few wild samples, which contained higher total sugar than the mean values of cultivated types. Shawakfeh and Ereifej (2005) reported that sugar contents varied significantly between two types from Jordan. It was indicated that carob pods contained sucrose, fructose and glucose, regardless of the variety and origin. Our observation corroborates the findings of Karkacier and Artik (1995). Sucrose was main sugar, followed by fructose and glucose in all samples. The ratios of individual sugars to total sugars indicated that both types were generally similar to each other. As a result, it appears necessary to identify extreme wild types, including high seeds and low pod, and cultivated

Table 1
Some physical and pomological features of carob samples

Features	Cultivated ($n = 22$)			Wild ($n = 31$)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Bean weight (g)	19.74	31.92	24.77 ± 0.65	5.84	23.28	13.51 ± 0.87
Bean length (cm)	14.98	19.60	17.68 ± 0.27	11.73	22.47	17.66 ± 0.51
Bean width (cm)	2.13	2.52	2.29 ± 0.02	1.41	2.51	1.85 ± 0.05
Bean thickness (mm)	7.07	11.38	9.50 ± 0.22	4.23	8.87	6.54 ± 0.21
Number of seeds	6.13	13.00	10.83 ± 0.31	9.93	17.93	13.17 ± 0.29
Seed weight (g)	0.88	2.54	1.93 ± 0.09	1.31	3.16	2.19 ± 0.08
Seed/pod ratio (%)	3.03	10.02	7.77 ± 0.42	10.29	28.43	17.77 ± 0.89

Table 2
Main sugar profiles of the pods of carob types

Main sugar (g/kg)	Carob type					
	Cultivated ($n = 22$)			Wild ($n = 31$)		
	Minimum	Maximum	Mean	Minimum	Maximum	Mean
Fructose	67.1	179	115 ± 27.1^{a}	59.9	176.9	102 ± 28.0^{a}
Glucose	14.5	70.0	33.0 ± 16.2^{a}	7.2	90.7	36.8 ± 16.2^{a}
Sucrose	298	635	384 ± 76.4^{a}	172	464.5	299 ± 75.9^{b}
Total	396	823	531 ± 93.2^{a}	282	564.8	437 ± 76.9^{b}
Fructose/total			0.22			0.23
Glucose/total			0.06			0.08
Sucrose/total			0.72			0.68

Values in a row followed by different letters are significantly different ($p < 0.05$).

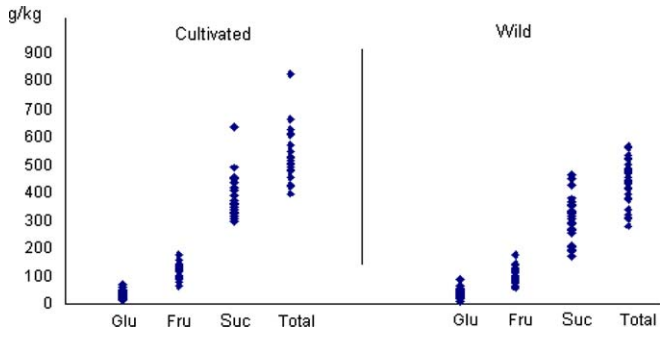

Fig. 1. Scattering plot of sugar profiles of cultivated and wild carob types (Glu: glucose; Fru: fructose, Suc: sucrose).

types containing low seeds and high pod rich in sugar, to give a better overview of the sugar profile of the varieties.

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