Scientific Bulletin. Series F. Biotechnologies, Vol. XIX, 2015
ISSN 2285-1364, CD-ROM ISSN 2285-5521, ISSN Online 2285-1372, ISSN-L 2285-1364

MINERAL COMPOSITION OF PODS, SEEDS AND FLOUR OF GRAFTED CAROB (CERATONIA SILIQUA L.) FRUITS

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Abstract

Carob pods are the fruits of the carob tree (Ceratonia siliqua L. Fabaceae). They are used for various purposes, including pharmaceutical industry, decoration, for human nutrition and for animal feed. Grafted carob fruits and one of the traditional products, produced from it- carob flour, were evaluated for their mineral composition. The carob consists of two parts, including pulp and seeds. The pulp represents 90% of the fruit. Carob powder is used as an ingredient in cakes and cookies and as cocoa substitute. Among the analyzed major minerals, Mg (859.0 mg/kg dry weight) was the most abundant element, and the pulp and seeds were also rich in Fe and Zn. Carob flour contained these elements in high amounts. This study has corroborated the notion that carob fruit and flour are rich sources of minerals and the seeds generally have higher amount of macro and micro minerals than the pulp.

Key words*: mineral composition; carob; Ceratonia siliqua L.*

INTRODUCTION

Carob fruits are among the most important tree fruit crops in the Mediterranean region and their production and consumption have increased considerably in recent years. The carob (Ceratonia siliqua) is slowly growing, woody and widespread plant. It is in general currency in Arabia and Oman, while it was introduced in California, Mexico and Southern Australia (Marakis et al., 1988) and is also distributed in some parts of Bulgaria - Black Sea coast, the Balkan Mountains, south central and northeaster Bulgaria. *Ceratonia siliqua* is considered a phylogenetically primitive species of tropical origin that has been cultivated in the Mediterranean area since historic times (Zohary, 2002). It is an economically important plant (Biner et al., 2007; Makris and Kefalas, 2004; Ozcan et al., 2007), which has been used for afforestation in half-withered regions (Catarino, 1993; Tous et al., 2009). The pod is light to dark brown, oblong, flat, straight or slightly curved, with a thick margin, and range from 10 to 20 cm in length and 1.5–2 cm in width. The unripe pod is green, moist and very astringent, but the ripe pod is sweet. The broken pod has a characteristic odour caused by its 1.3% isobutyric acid content (Morton 1987). Carob fruit generally consists of 80–90% pulp and 10–20% seed (Naghmouchi et al., 2009; Tetik et al., 2011a) and also contains 50–65% sugars (mainly composed of sucrose), 1–5% proteins and 0.2–08% lipids as well as crude fiber (11%) and significant amount of minerals (1–6%) (Avallone et al., 1997; Ayaz et al., 2007; Ozcan et al., 2007; Yousif and Alghzawi, 2000). Considering the mineral content of fruit, calcium, potassium, magnesium, sodium, phosphorus and iron are abundant (Eksi and Artik, 1986; Ozcan et al., 2007).

For many centuries, carob pods have been used in many countries for both human and animal nutrition. The use of carob pods in food dates back to ancient times, where the pulps are reported to have been consumed in raw form (Brandt, 2002; Haber, 2002; Owen et al., 1987). The fruit of the carob tree has recently become a valuable commodity and has been evaluated for multipurpose uses such as gum, syrup, powder, biofertilizer, d-pinitol, ethanol, mannitol, lactic and citric acid (Batu, 2005; Baumgartner et al., 1986; Carvalheiro et al., 2011; El-Shatnawi and Ereifej, 2001; Medeiros and Lannes, 2009; Parrado et al., 2008; Petit and Pinilla, 1995; Roukas, 1998; Tetik et al., 2011b;Turhan et al., 2010a,b, 2006).

They are widely used in the boiled juice (syrup) production.

Carob seeds are extremely hard and carob endosperm contains 30–40% by weight of galactomannan that is a polysaccharide

molecule composed mannose and galactose sugar units. So, the seeds (10%) are used industrially for carob bean gum or locust bean gum production.

The other major food source derived from carob is the powder with high protein content. Its structure is very suitable for cabinet making, and to make utensils as well as charcoal. It is also used as fodder and material in the tannery industry. Carob powder is a natural sweetener with flavour and appearance similar to chocolate; therefore it is often used as cocoa substitute. The advantage of using carob as a chocolate substitute is that carob powder ingredient free from caffeine and theobromine. In Europe several carob commercial products can be found as form of roasted carob flour used as a cocoa substitute in baking, cereal bars, chocolate confectionery, ice creams and light products. Other products, such as carob germ flour contains high protein content, almost 50%, with a high content of lysine and arginine. Carob germ flour is used as dietetic human food (Dakia et al., 2007) or as a potential ingredient in cereal-derived foods for celiac people (Feillet & Roulland, 1998). This low-cost product is highly rich in valuable compounds, particularly polyphenols, which have been described to present antioxidant activity and potential health benefits in humans. Therefore, the present study was undertaken to examine the nutritive properties as determine the mineral composition of grafted carob pods, seeds and flour.

MATERIALS AND METHODS

In the study were used grafted carob fruits which were collected from Mersin, Turkey and they were harvested at the end of the summer season of 2014. Carob fruits were randomly chosen and used in the analyses. The samples were broken into pulps and seeds with a pair of secateurs and were stored at 4^0C before analysis. It was studied a raw carob flour, obtained from carob pods, which was provided also from region of Mersin, Turkey.

Macro (magnesium-Mg) and micro (iron- Fe, copper-Cu, manganese-Mn, zinc-Zn, selenium-Se) minerals of carob samples were determined according to validated laboratory method (in Food Research and Development Institute Plovdiv). For this purpose, samples were washed with tap water and deionized water.

The method used - ICP-OES is based on the pulverizing of acid mineralization of studied products in inductively coupled plasma, where is carried out the excitation of chemical elements' atoms and subsequent measurement of their specific emission at specific wavelengths. The measured intensities are compared with the intensity of series of standard solutions containing determined elements measured under the same conditions.

Protocol of analysis: it was weighted to 1 g of samples and they put to microwave mineralization. It is carried out with microwave system in hermetically sealed pressure vessel. In Teflon vessel are added the samples, 2 to 3 ml of 0.2% solution of HNO_3 and 2 to 3 ml H_2O_2. Mineralized sample is filtered through a paper filter into a volumetric flask of 10 cm^3 and fill up with 0.2% solution of nitric acid.

RESULTS AND DISCUSSIONS

The chemical composition and mineral content of carob fruits have been studied. According to Ozcan et al. (2007), carob fruit (pulps and seeds) and flour are rich in carbohydrates, proteins and also are a good source of K, Ca, Na, Fe, and Mg. According to the literature data many factors affect the chemical composition of the fruit as well as its mineral content, for example, temperature, dryness (Nunes et al., 1992), irrigation and fertilization (Correia and Martins-Loucao, 1997) and salinity (El-Dengawy et al., 2011). The distribution of the macro and micro minerals obtained from the analysis of the carob samples is summarized in Table 1.

Table 1. Mineral content of carob pulps, carob seeds and carob flour

№	Mineral content (mg/kg)	Carob-pulps	Carob-seeds	Carob flour
1.	Selenium	1.60	1.60	1.60
2.	Magnesium	265.0	859.0	346.0
3.	Iron	16.80	82.0	76.60
4.	Copper	5.60	20.2	6.80
5.	Manganese	4.42	50.8	8.90
6.	Zinc	10.80	21.0	11.90

When carob samples (pulps, seeds, flour) were compared in terms of minerals, the seeds of the grafted samples generally contained higher mineral concentrations. Magnesium was the mineral with the highest concentration (between 265 mg/kg and 859 mg/kg) in all samples. Among the micro minerals, Fe had the highest concentration (between 16.80 mg/kg and 82.0 mg/kg) in the grafted carob fruit seeds and also they generally contained higher macro and micro minerals than the fruit pulp (Fig. 1 and Fig.2). Ayaz et al. (2007) studied the chemical composition of Anatolian carob pods and found the mineral concentration in the samples to be: 60 mg/100 g Mg, 1.88 mg/100 g Fe, 1.29 mg/100 g Mn and 0.85 mg/100 g Cu. Ozcan et al. (2007) studied carob fruits supplied by a local carob processing plant in Antalya and analyzed the chemical composition and mineral content of the fruits and their different products.

According to their results, the concentrations of minerals were lower to those in this study. But, they also reported higher concentrations of Fe (40.02 mg/kg), besides lower concentrations of Cu (2.29 mg/kg) and Zn (0.25 mg/kg) compared to our results. Youssef et al. (2013) also reported the concentration of macro and micro elements (9.69 mg/kg Mn, 4.58 mg/kg Cu) in carob powder produced by carob fruits collected in Egypt. Gubbuk et al. (2010) studied with wild and grafted (Etli and Sisam genotypes) carob fruits grown in Antalya.

Thus, our results are compatible to those in the literature.

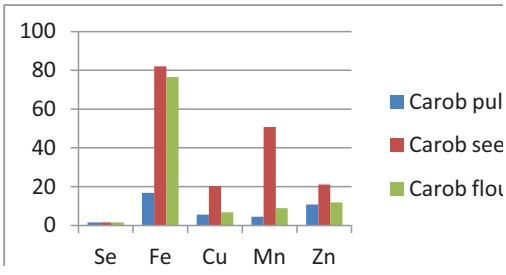

Figure 1. Micro minerals (mg/kg) of pulps, seeds and flour of *Ceratonia siliqua.*

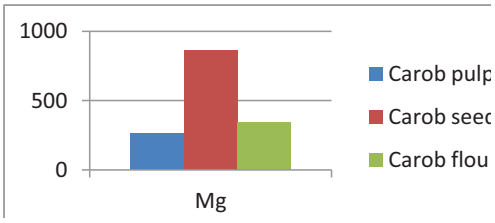

Figure 2. Magnesium content (mg/kg) of carob pulps, seeds and flour.

CONCLUSIONS

The results presented here show significant differences between fruit parts (pulp or seed) and raw carob flour. According to the results; the seeds of the grafted types had higher concentrations of the analyzed macro and micro minerals and all the samples are good sources of Se. The highest Mg concentration was observed in the seed of carob fruit (859 mg/kg). Furthermore, Fe, Mg and Zn levels as well as the Cu were higher in the seeds of the grafted carob types. The results obtained of this study prove that the carob fruits and flour, actually could be used as a good supplement in the healthy human diet.

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