Original article

Medicinal and nutritional analysis of fig (*ficus carica*) seed oil; a new gamma tocopherol and omega-3 source

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Summary. *Ficus carica (common fig)* is a tree native to southwest Asia and the eastern Mediterranean and is among the first plants cultivated by humans. Fig harvest is of worldwide importance for their dry and fresh consumption. The fruit, roots, and leaves of figs are used as anti-inflammatory and antispasmodic drugs for treating various disorders such as gastrointestinal (colic, dyspepsia, anorexia, and diarrhea), respiratory (a sore throat, cough, and bronchial problems) and cardiovascular disorders in traditional medicine. Previous studies have reported the use of latex, leaves, fruit, and root of the fig in the literature. However, so far, fig seeds (*Ficus carica*) have not been decomposed and analyzed for their oil content. High-Performance Chromatography Fluorescence Detector (HPLC-FLD) method was used to measure the level of vitamin E tocopherol, and the fatty acid content was analyzed with Gas Chromatography with Flame Ionization Detector (GC-FID) method. The results showed that *Ficus carica* seed oil is a rich source of linolenic acid (C18:3), linoleic acid (C18:2) and oleic acid (C18:1). Besides, it contains 314.61±51.53 mg/100 g gamma tocopherol. Thus, *Ficus carica* seed oil is of importance in the health sciences.

Key words: Ficus Carica, Fig Seed Oil, Omega-3, Gamma Tocopherol

Introduction

Ficus carica, commonly known as fig, is a tree indigenous to Southwest Asia and Eastern Mediterranean and one of the first plants cultivated by humans. It is an important produce consumed worldwide in both its fresh or dried form (1). Regions with warm winters and dry and hot summers such as Turkey, Morocco, Egypt, Spain, Greece, California, Italy, and Brazil are among the major producers of edible fig (2).

The fruits, roots, and leaves have been used in traditional medicine to treat gastrointestinal (colic, indigestion, inappetence, diarrhea), respiratory (sore throat, coughing, bronchial diseases), and cardiovascular diseases in addition to their use as anti-inflammatory and anti-spasmodic drugs (1). The reputation and use of *Ficus carica* as a traditional curative in various fields have attracted attention to its chemical composition (1,3-8). The phytochemical studies on *Ficus carica* have mostly focused on the phytosterols, anthocyanins, amino acids, organic acids, fatty acids, phenolic compounds, hydrocarbons, aliphatic alcohols, volatile compounds, and a few other classes of secondary metabolites derived from its different parts. Oliveira et al. (9) investigated and compared the chemical composition and biological potential of the pulps, peels, and leaves of two *Ficus carica* cultivars. Other studies examined the sterols, phenolic compounds, volatile compounds, organic acid composition, antioxidant capacity, antimicrobial potential, and fatty acid profile of the fruit latex and leaves, fruits, and roots of fig (10-22).

Since fig seeds are too small to chew or eat, it is not possible to use them as a beneficial food source. They are indigestible and usually eliminated from the body via feces. *Ficus carica* is a fig cultivar produced in the Aegean region and its seeds are surrounded by the fruit and pulp. The seeds of the figs produced in other regions of the Mediterranean are hollow and not meaty. To the best of our knowledge, the separation and analysis of the fat composition of the seeds of *Ficus carica* (common fig) have not yet been performed. The present study was conducted to isolate and analyze the fat composition from fig seeds and determine its potential uses. Thus, as a fig cultivar mostly produced in Turkey, the study will shed light to the uses of *Ficus carica* as a functional food.

Materials and Methods

Materials

The figs that had dried on their branches and fallen on the ground in the late summer were collected in Aydın, Turkey. These figs were dried on a grill and used as the study material.

Extraction of pure fig oil

The dust and dirt on naturally dried figs were rinsed off. After the release of moisture, the figs were cut into small pieces smaller than 5 mm. After rinsing, precipitation, and drying, the figs were separated from their seeds and the seeds were dried under natural conditions. The dried seeds were extruded in a specially-made cold-extrusion oil machine with an operating temperature below 25 °C to obtain the pure seed oil of *Ficus carica*. Then, the pure seed oil was kept at -18 °C until analysis. All analyses of two samples were also carried out in duplicate (n=4).

Fatty acid analysis

A gas chromatography-flame ionization detector (GC-FID) was used to determine the saturated, unsaturated, and trans fatty acid content of the fig seed oil. Ten milligrams of the oil were weighed, dissolved in 2 ml isooctane, and then, 2-N 100 µL methanolic KOH solution was added. After stirring for 10 minutes, the solution was centrifuged and the supernatant was injected into the GC-FID device. The GC analyses were performed using HP 6890 (USA) under the following conditions: column, SUPELCO SP TM-2560 100.0 m 0.25 mm 0.20 µm; an oven temperature program in which the initial temperature of 140 °C was increased by 4 °C/min to 240 °C and the solution was kept at this temperature for 5 minutes was followed. The injection temperature was 250 °C; the detector (FID) temperature was 260 °C; the carrier gas was He; injection volume was 1 µm.

The identification of the chromatographic peaks was achieved by comparing the retention times of the Supelco, USA (18919) 37 component FAME mix (C4-C24) standard. The calculations were given in composition% by determining the ratios of the peaks to each other regarding areas.

Tocopherol analysis

Tocopherol analysis was performed in the Agilent 1100 (USA) high-pressure liquid chromatograph coupled with a fluorescence detector. With this method, the total vitamin E and alpha, beta, gamma, and delta tocopherol contents were measured. In a 10-ml volumetric flask, 0.500 g (± 0,001 g) fig seed oil was weighed, brought to 10 mL with hexane, and vortexed. About 1 mL of the sample solution was transferred to a vial. The solution was injected into the HPLC-FLD device. A 4.0 mm x 250 mm x5 µm column (LICHROSORB SI 60) was used in the HPLC system. The oven temperature was set to 25 °C. The wavelengths of the fluorescence detector were adjusted to an extinction of 290 nm and an emission of 330 nm. The mobile phase was Hexane/2-Propanol (99,5:0,5, v/v), the flow rate was 0.8 mL per minute, and the injection volume was 20 µl. The alpha, beta, gamma, and delta tocopherol amounts were calculated concerning the peak areas of the standard calibration curves. The working ranges of the standards were 0.05 mg/L - 0.10 mg/L - 0.25 mg/L - 0.50 mg/L - 1.00 mg/L-2.5 mg/L for alpha tocopherol; 0.05 mg/L - 0.10 mg/L - 0.25 mg/L - 0.50 mg/L - 1.00 mg/L-2.5 mg/L for beta tocopherol; 5.0 mg/L – 10.0 mg/L - 25.0 mg/L – 50 mg/L – 100 mg/L – 250 mg/L for gamma tocopherol; 0.05 mg/L - 0.10 mg/L - 0.25 mg/L - 0.50 mg/L - 1.00 mg/L-2.5 mg/L for delta tocopherol.

Results and Discussion

This is the first use of the fig seed oil-specific cold extrusion method to obtain oil from fig seeds. From 25 kg dry fig, a total of 25 kg seeds was obtained and from 1 kg of the seeds, 200 mL oil was obtained. The density of the fig seed oil was 0.924 g/mL. The following fatty acids were determined in the seed samples: caprylic acid, caproic acid, capric acid, undecanoic acid, lauric acid, tridecanoic acid, myristic acid, myristoleic acid, pentadecanoic acid, cis 10 pentadecanoic acid, palmitic acid, palmitoleic acid, heptadecanoic acid, cis 10 heptadecanoic acid, stearic acid, oleic acid, linoleic acid, arachidic acid, gondoic acid, linolenic acid, heneicosanoic acid, cis 11,14 eicosadienoic acid, behenic acid, cis 8,11,14 eicosatrienoic acid, tricosanoic acid, arachidonic acid, cis 13,16 docosadienoic acid, lignoceric acid, cis 5,8,11,14,17 eicosapentaenoic acid, nervonic acid, cis 4,7,10,13,16,19 docosahexaenoic acid, trans oleic acid, trans linoleic acid, and trans linolenic acid content.

According to the analysis results, *Ficus carica* seed oil was rich in linolenic acid (18:3), linoleic acid (18:2), and oleic acid (18:1), contained relatively lower amounts of palmitic acid (16:0), and trace amounts of other oils (Table 1). Some fatty acids were not detected, which were: caproic acid (6:0), caprylic acid (8:0), capric acid (10:0), undecanoic acid (11:0), lauric acid (12:0), tridecanoic acid (13:0), myristoleic acid (14:1), cis-10-pentadecanoic acid (15:1), arachidonic acid (20:0), heneicosanoic acid (21:0), euric acid (22:1n9), cis-13, 16, docosadienoic acid (22:2), punicic acid, cis-5, 8, 11, 14, 17-eicosapentaenoic acid (EPA; 20:5n3), nervonic acid (24:1), cis-4, 7,10,13,16,19-docosahexaenoic acid (DHA; 22:6n3), and trans oleic acid.

The fruits of *Ficus carica* are consumed either fresh or dry or used to make jam. *Ficus carica* is widely accepted as an excellent source of minerals, vitamins, carbohydrates, and dietary fiber (12). Shiraishi et al. (23) reported that the leaves of *Ficus carica* comprise six types of organic acids including oxalic, citric, malic,

Table 1. The fatty acid composition of the seed oil obtained from *Ficus carica*

Fatty Acid	% Mean ± SD (n=4)
Alpha linolenic acid(C18:3) – Omega 3	41.75±1.01
Gamma linoleic acid (C18:2) –Omega 6	30.90±0.26
Oleic acid (C18:1) – Omega 9	15.98±0.73
Palmitic acid (C16:0)	7.61±0.19
Stearic acid (C18:0)	3.15±0.16
Fatty Acids in Trace Amounts	
Myristic acid (C14:0)	0.02±0.01
Pentadecanoic acid (C15:0)	0.02±0.00
Palmitoleic acid (C16:1)	0.07±0.01
Heptadecanoic acid (C17:0)	0.06±0.01
Gondoic acid (C20:1)	0.25±0.03
cis-11, 14-Eicosadienoic acid (C20:2)	0.04±0.01
cis-11, 14-17- Eicosadienoic acid (C20:3n3)	0.01±0.00
Behenic acid (C22:0)	0.08±0.01
Arachidonic acid (C20:4n6)	0.01±0.01
Lignoceric acid (C24:0)	0.03±0.01
cis-10-Heptadecanoic acid (C17:1)	0.02±0.01
Tricosanoic Acid (C23:0)	0.01±0.01

quinic, shikimic, and fumaric acid. However, the seed oil of *Ficus carica* has not yet been standardized. The nutritive value of fig seeds is lost as they are indigestible and eliminated in feces. Therefore, previous data on the production of fig seed oil and the standardized chemical content of the oil was not available for comparison with our results.

Oliveira et al. (24) showed that the fatty acid profile of the latex of *Ficus carica* was made up of 14 detectable major fatty acids. The comparison of the fatty acid profile of the latex with the fatty acid profile of the seed oil revealed that they both contained palmitic acid; however, the latex contained high amounts of palmitic acid, while the palmitic acid content of the seed oil was low. In general, the latex predominantly contains saturated fatty acids, while the seed oil contains polyunsaturated fatty acids. Jeong and Lachance (10) froze and homogenized the fruits of *Ficus carica* for determining the fatty acid content using gas chromatography for the dried fig, the most dominant fatty acid in dried fig fruit was linolenic acid (53.1%), followed by linoleic acid (21.1%), palmitic acid (13.8%), and oleic acid (9.8%). Since the figs used in the study were homogenized, the analysis also reflected the seed content of *Ficus carica*. Thus, our results concur with those of Jeong & Lachance. The analysis of the fatty acid compositions of the seeds of *Ficus carica* showed that they contained significant amounts of alpha-linolenic acid (omega-3, 41.75±1.01%), linoleic acid (omega-6, 30.9±0.26%), and oleic acid (omega-9, 15.98±0.73%). Linolenic acid and linoleic acid are essential fatty acids and together constitute about 70% of the fig seed fatty acids.

Considering its Vitamin E tocopherol content, with its 314.61±51.53 mg gamma tocopherol content per 100 g, the oil obtained from the seeds of *Ficus carica* was determined to be exceptional. The gamma-tocopherol content was followed by delta tocopherol (7.40±0.26 mg/100 g) and alpha-tocopherol (3.71±0.62 mg/100 g) contents; however, beta tocopherol (Table 2) was not detected.

Konyalıoğlu et al. (11) investigated the antioxidant capacity of the extracts derived from the leaves of *Ficus carica*. The alpha-tocopherol content of the extracts was determined using high-performance liquid chromatography with a UV detector (HPLC-UV).

Table 2. Tocopherol content of the Ficus carica seed oil

Tocopherol Type	mg/100 g Mean ± SD (n=4)
Alpha	3.71±0.62
Beta	Nd*
Gamma	314.61±51.53
Delta	7.40±0.26

*Nd: Not dedected

The alpha-tocopherol content of the n-hexane extract was 3.2788%, while it constituted 0.0570% of the dry weight of the leaves. The study showed that the leaves of *Ficus carica* contained alpha-tocopherol.

Soni et al. (25) investigated the phytochemical, antioxidant, and antibacterial activities of dried *Ficus carica* fruits. The dried fruits were powdered with a grinder. The volatile compounds of the fig fruits were determined using gas chromatography-mass spectrophotometry (GC-MS), and the results revealed that the fruits contained tocopherols and particularly gamma tocopherol along with other metabolites. It is clear that the dried fruits used in this study also contained the seeds. Thus, the gamma-tocopherol content determined in the study is attributable to the seeds. In this study, high levels of gamma-tocopherol were determined in the *Ficus carica* seed oil. Although canola, cantor oil, corn, olive oil, sesame, soya oil, and walnut oil contain 4.2, 11.1, 60.2, 0.7, 29.0, 79.7, and 59.5 mg/100 g gamma tocopherol, respectively (26-27), the gamma tocopherol content of the fig seed oil obtained in this study was determined to be 314.61±51.53 mg/100 g. Thus, the seeds of *Ficus carica* are an unparalleled source of gamma tocopherol.

Conclusion

Among the unsaturated fatty acids, fig seed oil contains significant amounts of both omega-3 and omega-6 fatty acids. The omega-3 fatty acid of fig seed oil is alpha-linolenic acid (ALA). Studies investigating ALA have shown that it is not only an essential oil but also has therapeutic properties.

The benefits of the gamma-tocopherol form of vitamin E have recently been discovered and because of its composition, the fig seed oil can be accepted as a valuable and unparalleled source of gamma tocopherol. The analysis showed that it contained much higher amounts of gamma tocopherol than many herbal seed sources. Since the tocopherol content of the fig seed oil predominantly stems from gamma-tocopherol, a direct comparison to the intake values calculated for alpha-tocopherol is not appropriate. The number of the studies investigating the toxicity of gamma tocopherol is not sufficient. Therefore, to determine the potential of fig seed for toxicity, studies focusing on gamma-tocopherol toxicity are needed.

Further evidence is required to propose new uses for fig seed oil considering the fatty acid and vitamin E analyses. Moreover, scientific evidences for both ALA and gamma tocopherol are needed. Furthermore, the clinical trials and experimental studies on fig seed oil should adopt a holistic approach to evaluate the potential synergistic effects of the macro and micronutrients in its content.

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