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Essential Oil Content and Composition of Fennel Fruits (*Foeniculum vulgare* Mill.)

[*1] Marzieh Negahban
[2] Sajedeh Saeedfar
[3] Vahid Rowshan
[4] Sharareh Najafian

[1] Islamic Azad University, Unit Jahrom, Jahrom, Iran
[2] Islamic Azad University, Unit Karaj, Karaj, Iran
[3] Research Center for Agriculture and Natural Resources of Fars Province, Shiraz, Iran
[4] Shiraz Payame Noor University, Shiraz, Iran
Corresponding author E-mail:* marziehnegahban_86@yahoo.com

Abstract

This study was carried out at the research field of Tarbiat Modares University, Peykan Shahr, Tehran to determine the content and chemical compositions of essential oil from fennel fruits at full ripening stage. The essential oil of dried fruits was extracted by hydrodistillation method using Clevenger apparatus, and analyzed by GC and GC-MS. The essential oil content of fruits was 1.1% at full ripening stage. The main oil components were *trans*-anethole (53.51%), carvacrol (11.93%), fenchone (8.32%), and timol (8.11%).

Keywords: *Foeniculim vulgare* Mill., essential oil, *trans*-anethole, carvacrol, fenchone, timol.

Introduction

Foeniculum vulgare Mill. is a biennial medicinal plant belonging to the family Apiaceae (Umbelliferae) spread in Mediterranean area and Central Europe. It is widely cultivated throughout the temperate and tropical regions of the world for its aromatic fruits which are used as a culinary spice. Essential oil (EO) of fennel is used as flavoring agents in food products such as beverages, bread, pickles, pastries, and cheese. It is also used as a constituent of cosmetic and pharmaceutical products. Herbal drugs and essential oils of fennel have hepatoprotective effects as well as antispasmodic effects. They are also known for their diuretic, anti-inflammatory, analgesic and antioxidant activities. Anand *et al.* (2008) reported that fennel seed possesses anticancer activity. Recently it was shown that fennel essential oil possesses emmenagogue and galactagogue properties and is a cure for pediatric colic and respiratory disorders due to its antispasmodic effects (Abdellati *et al.*, 2011). Herbal drugs and essential oil of fennel have antispasmodic, diuretic, anti-inflammatory, analgesic and antioxidant effects (Choi and Huang, 2004; Misharina and Polshkov, 2005; Parejo *et al.*, 2002). They are active for dyspeptic complaints, flatulence and bloating. The volatile oil showed antioxidant, antimicrobial and hepatoprotective activity (Toma *et al.*, 2008; Ozbek *et al.*, 2003; Aprotosoaie *et al.*, 2010). Mature fruit and essential oil of fennel are used as a

constituent of pharmaceutical and cosmetic products. They are also used as flavoring agents in food products. Essential oil composition depends upon external and internal factors affecting the plant such as: environmental and climate conditions, season of collection, age of plants, the stage of ripening of the fruits or genetic data (Bernath *et al*., 1999; Radulescu *et al*., 2009; Piccaglia and Marotti, 2001). Plasticity in the chemical composition of fennel essential oil in response to climatic factors, either in nature or under controlled conditions, is less known (Aprotosoaie *et al*., 2010).

This research was conducted in order to determine the content and essential oil chemical composition of fennel fruits at full ripening stage, collected in September 2014.

Material and Methods

The experiment was carried out at the research field of Tarbiat Modares University, Peykan Shahr, Tehran. Average annual precipitation at the site is 122.2 mm, minimum air temperature is -5 °C and maximum air temperature is 40.4 °C. The dominant winds at the area blow from Northeast. Some chemical characteristics of the experimental soils are shown in Table 1.

Table 1: Some physical and chemical characteristics of the experimental soil

EC ds m^{-1}	pH	OC[a] (%)	TN[b] (%)	P (mg kg^{-1})	K (mg kg^{-1})	Silt (%)	Sand (%)	Clay (%)
1.04	7.7	1.73	0.06	14	275	12	78	10

[a] Organic matter (OC), [b] Total nitrogen (TN)

Plant material

The ripe fruits were harvested in September 2014 from *Foeniculum vulgare* Mill. cultures.

Isolation of essential oil

The volatile oils were obtained from dried fruits by hydrodistillation in Clevenger apparatus (2 hours). The oil was separated, dried over anhydrous sodium sulfate and kept in a dark glass bottle at t= 4 °C for the analysis.

GC-MS analysis

GC/MS analysis of the essential oil was carried out using a HP5890 Series II Gas Chromatograph, HP 5972 Mass Selective Detector and Agilent 6890 Series Autosampler (Agilent Technologies, USA). A Supelco MDN-5S 30 m (meter) × 0.25 mm capillary column with a 0.5 µm film thickness was used with helium as the carrier gas at a flow rate of 1.0 mL/min. The GC oven temperature was programmed at an initial temperature of 40 °C for 5 minutes, then heated up to 140 °C at 5 °C /min and held at 140 °C for 5 min, then heated to 280 °C at 9 °C/min and held for five additional minutes. Injector and detector temperatures were set at 250 °C. Mass spectrometry was run in the electron impact mode (EI) at 70 eV. The identification of the chemical constituents of the oil was determined by their GC retention times, retention indices and interpretation of their mass spectra and confirmed by mass spectral library search using the National Institute of Standards and Technology (NIST) database with those of authentic samples or published data. The retention indices were calculated for all of the volatile constituents using a homologous series of C8–C20 *n*-alkanes. The identification of the components was based on comparison of their mass spectra in the apex of each peak with those of analytical standards from Willey Mass Spectral Library.

Results and discussion

The hydro-distillation of dried fruits of fennel (*Foeniculum vulgare* Mill.) at full ripening stage yielded 1.1% (w/w) EO. The results of the GC-MS analysis of EO at full ripening stage are shown in Table 2, in the order of their elution from a DB-5 column. In the present study, 17 compounds were identified in the EO representing 90.72% of the fruit volatile oil: *trans*-anethole (53.51%), carvacrol (11.93%), fenchone (8.32%), and timol (8.11%).

Table 2: Chemical Components of the Essential Oil Distilled from Fennel Fruits (*Foeniculum vulgare* Mill.) at full ripening stage

Compound	**Area %**	**RT***
1,8-cineole	4.07	4.29
α-pinene	0.29	5.01
β-pinene	0.52	5.09
limonene	0.31	8.69
cymene	1.32	6.31
γ-terpinene	0.03	9.09
camphene	0.11	9.23
myrcene	–	10.15
α-felandrene	–	10.38
α-terpinene	–	10.67
fenchone	8.32	11.10
γ-terpinene	0.01	11.37
camfor	0.03	13.05
terpinen-4-ol	0.25	13.83
estragole	3.01	14.57
α-terpineol	0.19	14.89
t-anethole	53.51	16.67
p-anisaldehyde	–	19.38
2,3,4,6-tetramethyl-phenol	0.03	19.83
timol	8.11	20.37
carvacrol	11.93	20.64

* RT – retention time (min)

Other major components found in fennel fruits were 1,8-cineole, cymene and estragole.

EOs and their components are generally recognized as safe (GRAS) for human and animal consumption under US Federal Regulations. The compositions of EOs might be affected by the developmental stage of the plant (Saharkhiz *et al.*, 2011; Saharkhiz *et al.*, 2009). According to the result of the present study, *trans*-anethole was the dominant compound of the oil at full ripening stage which is the same as results of Abdellaty *et al.* (2011).

Conclusion

According to our research the essential oil content of fennel fruits was 1.1% at full ripening stage. The main oil components were *trans*-anethole (53.51%), carvacrol (11.93%), fenchone (8.32%), and timol (8.11%).

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