Korean J. Medicinal Crop Sci. 11(4) : 274 - 278(2003)

Identification of the Major Volatile Components from Different Plant Organs of *Foeniculum vulgare* Mill.

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ABSTRACT : The various plant organs of fennel (*Foeniculum vulgare* Mill.) were investigated to identify their volatile components using Dynamic Headspace (purge & trap). They showed slight differences concerning the volatile components both qualitatively and quantitatively. Results revealed that trans-anethole (12.65%) was the major compound in the leaf. The highest compound was α-pinene (28.78%), and trans-anethole (7.90%) was highly detected in the stem. The maximum values were 5.64, 4.59, 1.58, 1.51, and 1.04% for α-pinene, γ-terpinene, β-pinene 1,8-cineol and fenchone, respectively in the flower. However, very little trans-anethole was detected (0.27%) in the flower. From these results, it was suggested that the major components were different depending on the plant organs. However it was demonstrated that the related plant organs like flower-fruit and leaf-stem contained the similar components.

Key words : *Foeniculum vulgare* Mill, Apiaceae, different plant organs, major volatile components, α-pinene, fenchone, anethole

INTRODUCTION

Foeniculum vulgare Mill. belongs to the Apiaceae family and was originally found at the around of Mediterranean Basin. Fennel has many local names in the Far Eastern countries, like "Sohoehyang" in Korea, "Xiao Hui Xiang" in China and "Shouikyo" in Japan. Bitter fennel *Foiniculum vulgare* Miller. var. *vulgare* is much more important for medicinal purpose than the sweet fennel var. *dulce*, which is mainly produced as condiment and for its essential oil (Aluwareh *et al.*, 1991). Fennel oil is characteristically clear yellowish-green liquid with a very sweet and slightly peppery odor. It has a warm spicy aromatic sweet and slightly burning flavor (Sudhir, 1982). Whole plant parts contain the essential oil and it has a sweet odor.

According to Robeva *et al.* (1998), the essential oil can be found in cavities, ducts or canals in the fruits of Apiaceae family. These ducts can be found in fennel fruits. Based on the chemotaxonomical investigations (Bernath *et al.*, 1996), it was proposed the differentiation of the fennel chemotypes resulted in fenchone rich (31~42%), methyl chavicole rich (30~43%), and (E) anethole rich (60~80%) types. Former publication (Muckensturm *et al.*, 1997) suggested that these three main compounds was also found in essential oil, fenchone (6.8~30.8%), methyl chavicol (2.6~36.3%), and (E) anethole (44.2~74.0%). The aim of this study was to demonstrate the biological characteristics and the chemical profiles of the different plant organs by using the Dynamic Headspace (purge & trap) to compare the major components with distilled essential oil.

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Received February 17, 2003 / Accepted October 20, 2003.

MATERIALS AND METHODS

Materials

Foeniculum vulgare subsp. *Capillaceum* var. *vulgare* used for the investigation, it was grown in the Medicinal Plant Garden of National Crop Experiment Station, RDA. The developmental phases of plant from July to August in 2002 was taken as samples. These dried under natural conditions and kept at 4℃ refrigerator until use. Anatomically, the seed and fruit of the Apiaceae species are grown as one. In practice, seeds have been often mentioned than the fruits. In this study, the seed and fruit are as the same. The vegetative plant organs (leaf, stem, flower) were taken at full flowering stage and reproductive organ (fruit) with stalks was taken at waxy ripening stage.

Methods (purge & trap)

Dried each plant organ/used 2 g
| concealed with 20 mℓ vial
put the vial into water bath (50℃)
| let the nitrogen into vial
| purging for 20 min.
Isolation by standard method for 50 min.
| flow the He 1 mℓ/min.
Identification of the separation chromatography
| by wily's library
Figure out the volatile components on each organ

Laboratory investigations

The volatile components were analyzed by capillary GC (Hewlett packard-Dynamic headspace, 5890). DB-5 25 M × 0.25 MM (film thickness 0.25 ㎛) column was used. The injector and detector temperatures were 220℃ and 250℃, respectively. The column temperature program was 60℃ (1 min.), 110~200℃ (3℃/min.), and 200℃ (20 min.) at starting temperature. The carrier gas was Helium, 1 mℓ/min. Identification of the volatile components were performed by GC/MSD, comparing their retention times with those of pure substances by peak enrichment with standards. In some cases parallel analysis was carried out by Wileys library (HP 5890/Ⅱ. GC-5971A MSD) in computer.

RESULTS AND DISCUSSION

The different plant organs showed slight differences concerning the volatile components both qualitatively and quantitatively. The major components were similar the studied plant organs. Trans-anethole was the major compound in leaf showing 12.65% of maximum value (Table 4 and Fig. 1). In leaf, other components were α-phellandrene (10.79%), 3-hexen-1-ol, acetate (6.79%), para-cymene (3.68%), and myrcene (3.15%). Limonene which has anticancer effect, was detected very little (0.48%), compared with the value (2.83%) in fruit. In stem, the highest compound was α-pinene (28.78), but trans-anethole was also very high (7.90%) and other components were 1-phellandrene (19.92%), paracymene (7.36%), α-phellandrean (4.75%), thujone (3.23%), myrcene (2.27%), β-pinene (2.65%), camphene (1.36%), and the other minor components were less than 1% (Table 1). In flower, the maximum value was α-pinene (5.64%), and other components were r-terpinene (4.59%), β-pinene (1.58%), 1,8-cineol (1.51%), l-fenchone (1.04%). However, the trans-anethole was very low in this organ (0.27%) compared with the other organs (4.98 ~12.65%). The other components were very low (camphene 0.60 ~ estragole 0.03%) (Table 2 and Fig. 2). In fruits, the maximum value was thujone (33.49%) and the trans-anethole (4.98%) was one of the major compounds. Other major components were estragole (4.49%), α-pinene (4.08%), thujone (3.49%), limonene (2.83%), myrcene (1.02%), and other minor components β-pinene (0.36%), and 1,8-cineole (0.06%) which was only found this organ (Table 3). Comparing the major and minor components of the similar related organs like the flowers and fruits, the highest compound were seen to be less than 6% in both organs. The major volatile components α-pinene, β-pinene, and trans-anethole were detected on each plant organ. Among the major volatile components, β-myrcene, 1-phellandrene and para-cymene were detected in leaf, stem, and flower, but not the fruits. However, camphene was not found

Table 1. Identification of the major volatile components in stem of *Foeniculum vulgare* Mill. by Dynamic Headspace (purge & trap).

Peak No.	Retention time	Components	Area	Quality (%)	Contents (%)
1	14.50	α-pinene	1032	97	28.78
2	15.19	Camphene	496	98	1.36
3	17.07	β-pinene	953	97	2.65
4	18.61	Myrcene	992	97	2.76
5	19.48	1-phellandrene	7142	95	19.92
6	20.15	α-terpinene	345	97	0.96
7	20.91	Para-cymene	2640	94	7.36
8	21.14	α-phellandrene	1817	95	4.75
9	21.92	*trans*-ocimene	179	97	0.50
10	23.20	γ-terpinene	147	97	0.41
11	25.46	Thujone	1167	93	3.23
12	27.46	Fenchone	23	83	0.06
13	33.56	Estragole	282	99	0.79
14	40.11	*trans*-anethole	2836	98	7.90

Table 2. Identification of the major volatile components in flower of *Foeniculum vulgare* Mill. by Dynamic Headspace (purge & trap).

Peak No.	Retention time	Components	Area	Quality (%)	Contents (%)
1	14.93	α-pinene	18681	97	5.64
2	15.46	Camphene	2007	98	0.60
3	17.380	β-pinene	5257	97	1.58
4	19.08	1-phellandrene	999	95	0.29
5	21.75	Para-cymene	3027	93	0.87
6	21.95	1,8-Cineole	5268	99	1.51
7	22.31	*trans*-ocimene	3192	97	0.95
8	23.90	α-terpinene	1521	97	4.59
9	27.33	1-Fenchone	3597	95	1.04
10	30.41	1-camphor	611	98	0.18
11	32.29	γ-terpene	1358	96	0.41
12	34.53	Estragole	110	98	0.03
13	35.41	Fenchyl acetate	109	91	0.03
14	36.37	Fenchone	445	78	0.13
15	37.55	1-Methoxy-4-[1-E-propenyl]benzene	881	97	0.26
16	41.60	*trans*-anethole	8268	98	0.27

Table 3. Identification of the major volatile components in fruits of *Foeniculum vulgare* Mill. by Dynamic Headspace (purge & trap).

Peak No.	Retention time	Components	Area	Quality (%)	Contents (%)
1	14.48	α-pinene	3850	97	4.08
2	15.27	Camphene	670	98	0.70
3	17.15	β-pinene	345	97	0.36
4	18.58	Myrcene	965	96	1.02
5	19.24	1-phellandrene	573	94	0.60
6	21.14	Limonene	2722	98	2.83
7	21.39	1,8-cineole	596	98	0.60
8	23.30	γ-terpinene	549	97	0.58
9	26.30	Thujone	3145	95	3.49
10	27.43	Fenchyl alcohol	191	97	0.20
11	29.55	L-camphor	672	98	0.70
12	33.82	Estragole	4223	98	4.49
13	41.07	*trans*-anethole	6116	98	4.98

Table 4. Identification of the major volatile components in leaves of *Foeniculum vulgare* Mill. by Dynamic Headspace (purge & trap).

Peak No.	Retention time	Components	Area	Quality (%)	Contents (%)
1	15.11	α-pinene	84	97	0.09
2	17.35	β-pinene	4395	97	5.20
3	18.70	Myrcene	2673	96	3.15
4	19.55	1-phellandrene	1132	94	10.79
5	20.27	3-Hexen-1-ol,acetate	9123	83	6.79
6	21.00	Para-cymene	5743	95	3.68
7	21.22	Limonene	3180	98	0.48
8	22.02	*cis*-ocimene	420	97	0.02
9	23.46	γ-Terpinene	24	97	0.42
10	31.83	Naphthalene	94	94	0.10
11	33.54	Estragole	910	99	1.07
12	37.79	B-phenylethyl acetate	127	90	0.14
13	40.10	*trans*-anethole	1069	98	12.65

at the leaf and other investigated organs. Thujone was detected only in the stem (3.23%) and the fruit (3.49%). Limonene was detected in the leaf (0.48%) and the fruit (2.83%). 1,8-Cineol was found only in the flower and the fruit. Fenchone, one of the pungent odors used for its medicinal properties, was detected only in the flower, which did not coincide with Chung's result (Chung *et al.*, 1999). Chung mentioned that the

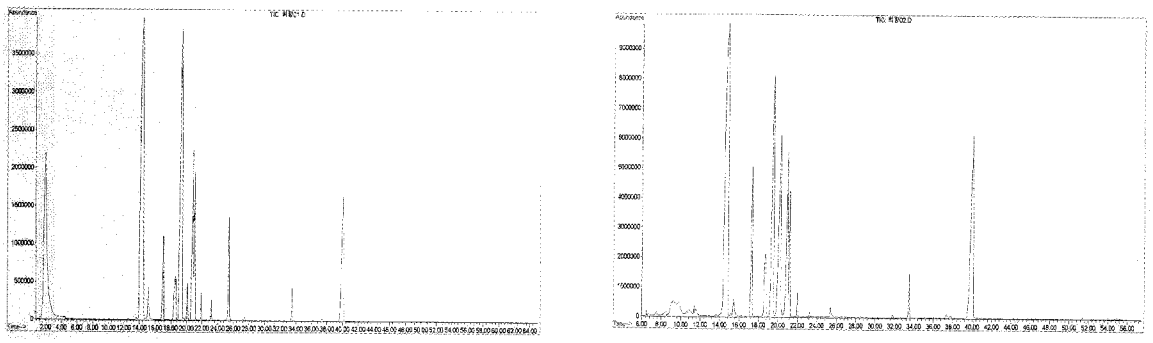

Fig. 1. Isolation chromatography of different plant organs (left, stem; right, leaf) by Dynamic Headspace (purge & trap) of *Foeniculum vulgare* Mill.

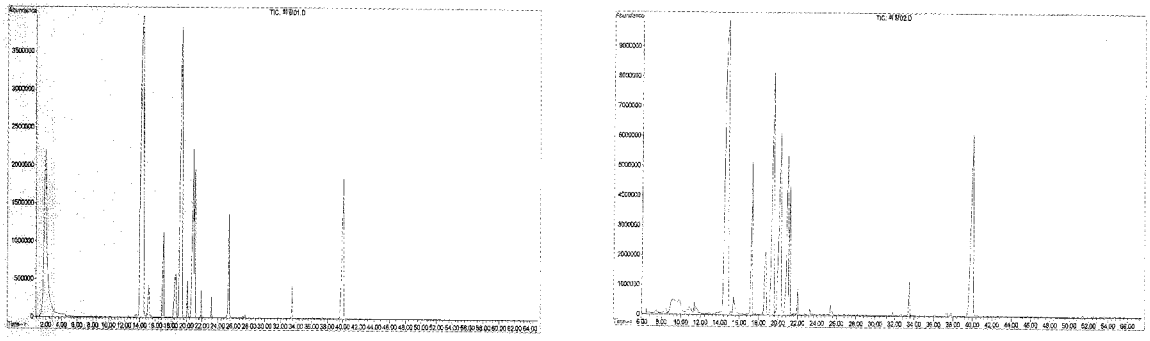

Fig. 2. Isolation chromatography of different plant organs (left, flower; right, fruit) by Dynamic Headspace (purge & trap) of *Foeniculum vulgare* Mill.

fenchone was detected in all plant parts except the stem, which was traced at the full flowering stage. With this result, present study suggested that the major components mainly depend on the plant organs. The related two plant organs like flower and fruit and leaf and stem, were shown to have the similar component and content.

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