Food Chemistry **30** (1988) 319–323

Research Note

Comparative Volatile Oil Composition of Various Parts from Turkish Bitter Fennel (*Foeniculum vulgare* var. *vulgare*)

ABSTRACT

The volatile oil composition of various parts of bitter fennel (Foeniculum vulgare *var.* vulgare) *growing as wild Turkish plants was investigated by gas–liquid chromatography. The major component of all oil samples was* trans-*anethole (29·70, 37·07, 54·22, 61·08, 64·71% in leaf, stem, flowering umbel, flower, fruit, respectively). The other main components were α-pinene in leaf, stem, flowering umbel, flower: α-phellandrene in leaf, stem, flowering umbel; fenchone in fruit oil. The volatile oils of flowering umbel, flower and fruit contained high amounts of oxygenated compounds, in gradually increasing percentages.*

INTRODUCTION

The genus *Foeniculum* (fam. *Umbelliferae*) includes some varieties amongst which bitter fennel [*F. vulgare* Mill. var. *vulgare* (Mill.) Thell.] is an indigenous perennial plant growing wild in several localities of Turkey (Davis, 1972). The fresh leaves and dried fruits of this plant are used as a spice for meat, baked and confectionery products, and as a local *materia medica in* Turkey.

Many researches have been carried out on the chemical composition of volatile oils of sweet fennel, var. *dulce* (Karlsen *et al.*, 1969; Tsvetkov, 1970; Ashraf & Bhatty, 1975; Conan, 1977; Fujita *et al.*, 1980; Ravid *et al.*, 1983), vegetable fennel, var. *azoricum* (Stahl, 1982), and bitter fennel, var. *vulgare* (Rothbacher & Kraus, 1970; Trenkle, 1972; Kraus & Hammerschmidt,

Food Chemistry 0308-8146/88/$03·50

1980) from various origins. The principal flavouring constituents of all fennel fruit oils are *trans*-anethole and fenchone, but the other parts of the fennel plants have somewhat different chemical compositions (Heath, 1981).

In previous studies, we investigated the fruit volatile oils of cultivated sweet fennel and the pepper fennel (ssp. *piperitum*) growing wild in Turkey, and found that *trans*-anethole in sweet fennel and estragole in pepper fennel were the major components (Doğan *et al.*, 1984; Akgül, 1986). For the present study, we analysed the volatile oils of different parts from wild-growing bitter fennel plant (*F. vulgare* var. *vulgare*). This report is the first research on Turkish bitter fennels.

MATERIALS AND METHODS

The stems, leaves, flowering umbels, flower and fruits of bitter fennel plants growing wild in Sinop (N. Turkey) were collected in June–September 1985. The plant material was identified by Dr A. Tatlı, Botany Department, Atatürk University, Erzurum. Dried and ground material of each plant part was subjected to hydro-distillation for 4 h using a Clevenger-type apparatus. The oil yields were 1·2, 1·7, 2·1, 2·2 and 5·6% in stems, leaves, flowering umbels, flowers and ripe fruits, respectively.

Volatile oil samples were analyzed by gas–liquid chromatography (GLC) using a Varian model 3700 gas chromatograph fitted with FID. Packed column: 10% Carbowax 20 M on Chromosorb W/AW 80–100 mesh, 4 m × 1/8 in (id) SS; flow rate of carrier gas, N_2:15 ml/min; initial column temperature: 80°C and then programmed to 195°C at 2°C/min and held for 15 min. Quantitation was carried out with a Varian model CDS 111 integrator. Identification of oil components was performed by means of authentic chemicals kindly supplied by Dr D. Lamparsky, GIVAUDAN SA, Geneva, Switzerland.

RESULTS AND DISCUSSION

The names and percentages of components identified by GLC in bitter fennel volatile oils are listed in Table 1.

trans-Anethole was the major component of flowering umbels, flowers and fruits: 54·22, 61·08 and 64·71%, respectively. In stems and leaves, the contents of *trans*-anethole were 37·07 and 29·70%. The other main components of stem, leaf and flowering umbel oils were α-pinene and α-phellandrene. Stem oil contained more γ-terpinene and *p*-cymene than the other plant parts. A high quantity of fenchone was found in the fruit oil.

TABLE 1
Percentage Composition of the Volatile Oils from Different Parts of Turkish Bitter Fennel (*Foeniculum vulgare* var. *vulgare*)

Component	*Stem*	*Leaf*	*Flowering umbel*	*Flower*	*Fruit*
α-Pinene	14·12	25·58	13·30	11·27	3·18
Camphene	0·23	0·53	t	0·65	0·93
β-Pinene	1·13	1·25	2·15	1·93	1·17
Myrcene	2·07	1·20	1·88	1·16	1·32
α-Phellandrene	13·20	25·44	10·72	5·97	1·15
Limonene	1·25	1·72	1·10	1·39	2·87
γ-Terpinene	10·16	1·14	1·02	0·94	0·83
p-Cymene	8·18	1·87	2·16	2·21	1·78
Fenchone	4·75	3·14	5·43	6·92	13·85
Estragole	2·15	3·11	2·28	2·94	4·96
cis-Anethole	t	t	0·23	0·28	0·38
trans-Anethole	37·07	29·70	54·22	61·08	64·71
Anisaldehyde	t	—	0·15	0·13	t
Anisketone	t	0·23	—	t	1·12

t, Traces (<0·1%).
—, Not detected.

Anisaldehyde and anisketone, the autooxidation products of *trans*-anethole, and *cis*-anethole were in trace or small amounts in oil samples. As a result, the flower and fruit oils were rich in oxygenated compounds.

The volatile oils of bitter fennel fruit are characterized by relatively high concentrations of α-pinene and fenchone and low concentrations of *trans*-anethole and estragole, unlike sweet fennel oils (Betts, 1968*b*; Karlsen *et al.*, 1969; Lawrence, 1979). Turkish bitter fennel fruit oil was very similar in *trans*-anethole and fenchone contents, to oils reported in the literature as 50–60% *trans*-anethole and 10–30% fenchone (Betts, 1968*b*; Heath, 1981; Formáček & Kubeczka, 1982). Betts (1968*a*) reported that *trans*-anethole and fenchone were present at all stages of development of sweet and bitter varieties and continuously increased. Trenkle (1972) showed that bitter fennel herb oils contained higher percentages of α-pinene and α-phellandrene, in agreement with our findings; however, *trans*-anethole contents of Turkish oil samples were lower. On the other hand, it was reported that sweet fennel herb oils had high concentrations of limonene (Conan, 1977; DeVottero *et al.*, 1980; Ravid *et al.*, 1983) and vegetable fennel root oil had a high amount of terpinolene (Stahl, 1982).

Our findings suggest that the stem, leaf and flowering umbel oils of Turkish bitter fennel have little value because of their low yields of oil, low percentages of *trans*-anethole and large amounts of hydrocarbons. The fruit

oil, with a high percentage of oxygenated compounds and low amount of *cis*-anethole seems to be a valuable flavouring agent for various food products.

REFERENCES

Akgül, A. (1986). Studies on the essential oils from Turkish fennel seeds (*Foeniculum vulgare* M. var. *dulce*). In: *Progress in Essential Oil Research*, ed. E.-J. Brunke. Walter de Gruyter, Berlin, pp. 487–9.

Ashraf, M. & Bhatty, M. K. (1975). Studies on the essential oils of the Pakistani species of the family Umbelliferae. Part II. *Foeniculum vulgare* Miller (fennel) seed oil. *Pakistan J. Sci. Ind. Res.*, **18**, 236–40.

Betts, T. J. (1968*a*). Anethole and fenchone in the developing fruits of *Foeniculum vulgare* Mill. *J. Pharm. Pharmac.*, **20**, 469–72.

Betts, T. J. (1968*b*). Examination of fennel fruits by gas chromatography without preliminary distillation. *J. Pharm. Pharmac.*, **20, Suppl.** 61S–4S.

Conan, J. Y. (1977). Essai de définition d'un label Bourbon pour quelques huiles essentielles de la Réunion. *Rivista Ital.*, **59**, 544–9.

Davis, P. H. (1972). *Flora of Turkey and the East Aegean Islands*, Vol. 4. University Press, Edinburgh.

DeVottero, L. R., Gros, E. G. & Retamar, J. A. (1980). L'huile essentielle de *Foeniculum vulgare* (fenouil). Paper No. 133, VIIIth International Congress of Essential Oils, Cannes, France.

Doğan, A., Bayrak, A. & Akgül, A. (1984). Biber rezenesinin (*Foeniculum vulgare* Mill. var. *piperitum*) tohum uçucu yağı üzerinde arastırma. *Ank. Üniv. Zir. Fak. Yıl.*, **34**, 314–9.

Formáček, V. & Kubeczka, K.-H. (1982). *Essential Oils Analysis by Capillary Gas Chromatography and Carbon-13 NMR Spectroscopy*. Wiley Heyden, Bristol.

Fujita, S., Asami, Y. & Nozaki, K. (1980). Miscellaneous contributions to the essential oils of the plants from various territories. Part XLVI. The constituents of the essential oils from *Foeniculum vulgare* Miller. *Nippon Nogei Kaishi*, **54**, 765–7.

Heath, H. B. (1981). *Source Book of Flavors*. Avi Publ., Westport.

Karlsen, J., Baerheim Svendsen, A., Chingova, B. & Zolotovitch, G. (1969). Studies on the fruits of *Foeniculum* species and their essential oil. *Planta Med.*, **17**, 283–93.

Kraus, A. & Hammerschmidt, F. J. (1980). An investigation of fennel oils. *Dragoco Report*, **1/2**, 3–12.

Lawrence, B. M. (1979). Progress in essential oils. *Perfum. Flavorist*, **4**, 53–6.

Ravid, U., Putievsky, R. & Snir, N. (1983). The volatile components of oleoresins and the essential oils of *Foeniculum vulgare* in Israel. *J. Nat. Prod.*, **46**, 848–51.

Rothbacher, H. & Kraus, A. (1970). Terpenkohlenwasserstoffe in Rumänischem fenchelöl. *Pharmazie*, **25**, 566–7.

Stahl, E. (1982). Atherisches öl aus gemusefenchel untersuchungen zur zusammensetzung. *Deut. Apothek. Zeit.*, **122**, 2324–6.

Trenkle, K. (1972). Neuere untersuchungen an fenchel (*Foeniculum vulgare* M.). 2. Mitteillung: Das ätherischen öl von fruct, kraut und wurzel fructifizierender pflanzen. *Pharmazie*, **27**, 319–24.

Tsvetkov, R. (1970). Study on the fruit quality of some Umbelliferous essential oil plants. *Planta Med.*, **18**, 350–3.

Attila Akgül*
Department of Food Science,
Faculty of Agriculture, Atatürk University,
25170 Erzurum, Turkey
& Ali Bayrak
Department of Food Science,
Faculty of Agriculture, Ankara University,
06110 Diskapi-Ankara, Turkey

(Received 16 December 1987; revised version received and accepted 19 February 1988)

* To whom all correspondence should be addressed at: Ziraat Fak, TÜT Böl., 25170 Erzurum, Turkey.