Analysis on Volatile Constituents in Leaves and Fruits of *Ficus carica* by GC-MS

LI Jun[1, 2], TIAN Yu-zeng[1], SUN Bao-ya[3], YANG Dan[4], CHEN Ji-ping[1*], MEN Qi-ming[2*]

1. Dalian Institute of Chemical Physics, Chinese Academy of Sciences, Dalian 116023, China
2. Dalian Institute for Food and Drug Control, Dalian 116021, China
3. Shenyang Agricultural Monitoring Center, Shenyang 110034, China
4. School of Pharmacy, Liaoning University of Traditional Chinese Medicine, Dalian 116600, China

Abstract: **Objective** To identify and analyze the volatile constituents in the leaves and fruits of *Ficus carica*. **Methods** Gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS) were used. **Results** The major components detected in volatile oil of the leaves were psoralen (10.12%), β-damascenone (10.17%), benzyl alcohol (4.56%), behenic acid (4.79%), and bergapten (1.99%), etc. The major components detected in volatile oil of the fruits were furfural (10.55%), 5-methyl-2-furaldehyde (10.1%), and benzeneacetaldehyde (6.59%), etc. **Conclusion** A total of 121 volatile constituents are identified in the leaves and 108 in the fruits of *F. carica*, among which 103 constituents are identified for the first time in the leaves and 100 in the fruits. Eighteen volatile constituents are identified in both leaves and fruits.

Key words: bergapten; *Ficus carica*; GC; GC-MS; psoralen; volatile oils
DOI: 10.3969/j.issn.1674-6384.2012.01.010

Introduction

Fig (*Ficus carica* L., Moraceae) is native to Western Asia. In China, it is cultivated in Shanxi, Jiangsu, and Shandong Provinces, etc. especially in Atushi city (Xinjiang, China), which is well known as “the county of figs” (Ren, Duan, and Abudu, 2000).

The nutritive and pharmacological values of figs have recently been studied in detail. Fig tree latex has a similar therapeutic effect as salicylic acid in the treatment of teat papillomatosis in cow (Hemmatzadeh, Fatemi, and Amini, 2003). A mixture of 6-*O*-acyl-β-*D*-glucosyl-β-sitosterols has been isolated as a potent cytotoxic agent from fig latex. The constituents showed *in vitro* inhibitory effects on proliferation of various cancer cell lines (Rubnov *et al*, 2001).

The antidiabetic effects of *F. carica* leaf extracts have also been reported. It was confirmed that the water extract and its chloroform fraction tended to normalize the anti-oxidant status which was affected in the diabetes syndrome (Pèrez, Canal, and Torres, 2003). From the aqueous decoction of fig leaves, the administration of the chloroform extract in rats with streptozotocin-induced diabetes led to a decline in the levels of total cholesterol and a decrease in the total cholesterol/HDL cholesterol ratio (with contrast to the control group), together with a reduction of hyperglycaemia (Canal *et al*, 2000). It continued the hypoglycaemic effect for 24 h after the effect of insulin administration had disappeared, which was presumed that there was probably a substance with an extra-pancreatic activity (Pèrez *et al*, 1996). It affected lipid catabolism in hypertriglyceridemic rats. The clearly positive results suggested that the fig leaves contained some substances capable of stimulating the lipolytic

* Corresponding authors: Chen JP Address: No. 457, Zhongshan Road, Dalian 116023, China
Tel/Fax: +86-411-8437 9562 E-mail: Chenjp@dicp.ac.cn
Men QM Address: No. 888A, Huanghe Road, Shahekou District, Dalian 116021, China
Tel: +86-411-8425 5200 Fax: +86-411-8425 5360 E-mail: mqm@dl.cn
First author: Li J Address: Dalian Institute for Food and Drug Control, No. 888A, Huanghe Road, Shahekou District, Dalian 116021, China
Tel: +86-411-8425 5257 Fax: +86-411-8425 5360 E-mail: sophie9cn@sina.com
Received: July 30, 2011; Revised: September 30, 2011; Accepted: October 21, 2011
Fund: the Project of Researches in Application and Development of Figs in Atushi aided by Atushi Agricultural Bureau in Xinjiang, China

activity of the plasma LPL system (Pérez *et al*, 1999), and they had hypoglycemic action on diabetic I patients (Serraclara *et al*, 1998). By ig administration of the aqueous extract of *F. carica* leaves, there was a decrease of glucose level, a prevention of body weight loss and an increase of survival index in diabetic rats (Pèrez *et al*, 1992). Plasma glucose and triglyceride levels were significantly decreased but the cholesterol concentration was not affected in rats with insulin-dependent diabetes (Dominguez *et al*, 1996).

The water extract from the leaves of *F. carica* possesses distinct anti-HSV-1 effect (Wang *et al*, 2004). Richter *et al* (2002) investigated the effects of proteases derived from *F. carica* (common fig) on human blood coagulation. The methanol extract and triterpenoids, such as calotropenyl acetate, methyl maslinate, and lupeol acetate are the most potent and persistent irritant, isolated from the leaves and exhibited irritant potential on mice ears (Saeed and Sabir, 2002).

Figs are an excellent source of minerals, vitamins, amino acids, and dietary fibre. They are fat- and cholesterol-free and contain a large number of amino acids. Figs were analyzed for total polyphenols, total flavonoids, and anthocyanins, and exhibited high anti-oxidant capacity (Solomon *et al*, 2006; Slavin, 2006).

The *n*-hexane-soluble extract with the anti-osteco-clastogenic activity was fractionated on a silica gel column and the most active fraction was analyzed by GC-MS (Park *et al*, 2009). Athnasios *et al* (1962) isolated psoralen, sitosterol, bergapten, and taraxasterol from the petroleum ether extract of the leaves. In an HPLC-PDA system, some phenolics such as gallic acid, chlorogenic acid, syringic acid, (+)-catechin, (−)-epicatechin, and rutin were identified (Veberic, Colaric, and Stampar, 2008). Triterpenes were also isolated (Ahmed, Khan, and Malik, 1988). Sugiura *et al* studied proteinases from *F. carica* (Sugiura *et al*, 1975; Sugiura and Sasaki, 1973; 1974). Some volatile constituents were isolated and identified from the leaves and fruits, respectively (Buttery *et al*, 1986; Gibernau *et al*, 1997; Grison-Pige *et al*, 2002; Oliveira *et al*, 2010; Zhao, Zhou, and Wu, 2004).

Medicinal plants are natural medicinal sources and afford great chances to obtain a prototype molecule due to their diversity of constituents. However, countless plants used in phytotherapeutic preparations need a serious of quality control, since many of them may present toxic substances or variable chemical composition (Galhiane *et al*, 2006). The scarcity of available data of the volatile constituents in *F. carica* prompted us to reinvestigate the constituents of essential oil in the leaves and fruits of this plant. The objective of this study was to extract the essential oil from the leaves and fruits of *F. carica*, using a simultaneous hydro-distillation and solvent-extraction in a Clevenger- type apparatus, and to identify and analyze the fragrant and effective constituents in the essential oils by GC-MS.

Materials and methods

Plant materials

The leaves and fruits of *F. carica* were collected respectively in August and late September, 2007 from Atushi city (Xinjiang, China). The identification of the plant materials was confirmed by Prof. ZHAI Yan-jun and the voucher specimens (leaves: DLIFDCL200701; fruits: DLIFDCF200701) were maintained at Dalian Institute for Food and Drug Control, China. The green leaves were air-dried for one week, and the fruits were dried at 60 ℃ for 4 or 5 d. They were stored at room temperature. The dried samples were ground using a mill to obtain coarse powder (20 meshes).

Apparatus and reagents

Finnigan Trace GC-MS 2000 (America), the National Institute of Standards and Technology Mass Spectral Database (NIST-MS, 2005); Agilent 5890 GC (America), FID Detector; Ultrasound Cleaning Bath (Sonorex, Super RK 255H type, 300 mm × 150 mm, 150 mm); a Clevenger-type apparatus.

Ethyl acetate (Shenyang Chemical Regent Factory, Liaoning, China), NaCl and anhydrous sodium sulphate (Tianjin Kemi'ou Chemical Regent Co., Ltd., China).

Isolation of essential oils

The powdered leaves and fruits were separately subjected to hydrodistillation for 6 h in a Clevenger-type apparatus. A solvent of ethyl acetate was used for extracting. The extract was dried over anhydrous sodium sulphate and filtered through Whatman No. 1 filter paper. The filtered extract was then concentrated at 40 ℃, and the resulted essential oils were stored at −20 ℃ prior to chemical analysis. The organic layer was transferred into a separatory funnel with 5 mL of saturated solution of NaCl added, the procedure was repeated for three times.

The separated organic layer was collected. The isolation of the essential oil was carried out in triplicate.

GC-MS analysis

The obtained essential oil from the fruits was analyzed using a Finnigan Trace GC-MS 2000 (EI mode, 70 eV). The separation was performed on a DB—5 capillary column (60 m × 0.25 mm, 0.25 μm). The essential oil from the leaves was analyzed using an HP 5890 gas chromatograph (GC) coupled with an HP 5972 mass spectrometer (EI mode, 70 eV), with an HP-FFAP capillary column (50 m × 0.32 mm, 0.25 μm).

Helium was used as the carrier gas at a flow rate of 0.5 mL/min with a splitting ratio of 50:1. The column temperature was programmed from 60 to 290 ℃ at 2 ℃/min, held at 60 ℃ for 10 min and at 290 ℃ till manually stopped. The injector and the interface temperature were 220 and 280℃, respectively. The *m/z* range was 29—450. The constituents were identified by NIST-MS, 2005. The relative amounts (RA) of individual constituents of the oil are expressed as the percent peak area relative to the total peak area.

GC-FID analysis

GC analysis was performed on a Hewlett-Packard Model 5890 Series II gas chromatograph equipped with a flame ionization detector and capillary column (PEG—20M; 50 m × 0.25 mm, 0.25 μm). Chromatographic conditions were as follows: nitrogen as carrier gas at 0.5 mL/min with a splitting ratio of 50:1; injector and detector temperatures, 220 and 260 ℃, respectively. Oven temperature was isothermal at 60 ℃ for 10 min, then increased to 260 ℃ at a rate of 2 ℃/min and then held at 260 ℃ till manually stopped.

Reference substances

The following reference substances were available: psoralen (National Institute for Food and Drug Control, China), and 5-methoxypsoralen (Sigma, USA).

Results and discussion

The volatile constituents in the leaves and fruits of *F. carica* were identified by GC-MS (Table 1). The compositions of the essential oils in the leaves and fruits were determined by GC-FID (Table 1).

More constituents were identified in the essential oils of both the leaves and fruits of *F. carica* in this study than the previous studies. A total of 121 constituents in the leaves and 108 in the fruits were identified. The leaves and fruits were different in compositions of the essential oils, but 18 components were shared in them (Table 1). The major components detected in the oil of the leaves were psoralen (10.12%), β-damascenone (10.17%), benzyl alcohol (4.56%), behenic acid (4.79%), and bergapten (1.99%), etc. The major components detected in the oil of the fruits were furfural (10.55%), 5-methyl-2-furaldehyde (10.1%), and benzeneacetaldehyde (6.59%), etc. In this study, 103 volatile constituents in the leaves and 100 in the fruits of *F. carica* were identified for the first time.

F. carica is widely used as flavors. Besides some aromatic constituents reported previously, some new aromatic constituents were isolated. In the essential oil from the leaves, 35 aromatic constituents were obtained, among which 30 were first reported. In the essential oils from the fruits, 29 aromatic constituents were isolated, of which 26 were first reported. Many of the aromatic components are widely used as flavors in food and cosmetics. Indole is the most frequently used among those volatiles, presents in fig (Knudsen, Tollsten, and Bergström, 1993).

In the essential oils, some constituents are active for some diseases. Psoralen, bergapten, and benzaldehyde were reported to be inhibitory on tumor cells (Okuyama *et al*, 1991). Psoralen and bergapten exhibited potent melanogenesis stimulation activity (Matsuda *et al*, 2005). Bergapten was reported to be more active to HeLa cells than to MK-1 and B16F10 cells (Fujioka *et al*, 1999). Bergapten showed cyclooxygenase-2 inhibitory activity with an IC_{50} value of 6.2 mg/mL (Yoo *et al*, 2002). Psoralen, bergapten, and benzaldehyde were identified in the essential oil of the leaves of *F. carica*, and psoralen and bergapten were in large amounts. Psoralen and bergapten could be considered as the index constituents for the determination of the quality in the leaves of *F. carica*.

For further study, the techniques for extraction and isolation need to be developed, and identification of the active constituent and exploration for some new bioactive components in various medicinal parts of *F. carica* need to be investigated in the future.

Conclusion

In this study, it proved that hydrodistillation in a Clevenger-type apparatus with solvent-extraction could

Table 1 Constituents detected from the essential oil in the leaves and fruits of *F. carica*

No.	Leaves			No.	Fruits		
	Compounds	t_R / min	RA / %		Compounds	t_R / min	RA / %
1[△]	2-methylpropyl acetate	8.20	0.08	1	dihydro-2-methyl-3 (2*H*)-furanone	7.60	0.55
2	2-methyl-3-buten-2-ol	8.95	0.09	2[△]	furfural	8.51	10.55
3	toluene	9.31	0.03	3[△]	ethyl isovalerate	8.77	—
4	crotonic aldehyde	9.60	—	4[△]	furfuryl alcohol	8.96	—
5[△]	acethyl propionyl	9.97	0.02	5[*△]	phenylethane	9.29	1.46
6[△]	butyl ethanoate	10.45	—	6	1,4-dimethyl benzene	9.57	0.99
7[p]	hexanal	10.99	0.09	7	2-cyclopentene-1,4-dione	10.15	0.43
8	4-methyl-1-penten-3-one	11.80	—	8[*△]	*o*-xylene	10.51	0.40
9[*△]	phenylethane	13.14	—	9	3-(methylthio)-propionaldehyde	10.98	—
10[△]	3-penten-2-one	13.32	—	10[△]	2-furylmethyl ketone	11.23	0.82
11[△]	4-methyl-3-penten-2-one	13.51	0.59	11	cumene	11.82	—
12[△]	*m*-xylene	13.93	—	12	*n*-propylbenzene	13.31	0.04
13[p]	1-penten-3-ol	14.49	—	13	*m*-ethyl-toluene	13.74	0.02
14[△]	citral	14.93	0.03	14[*]	5-methyl-2-furaldehyde	13.92	10.1
15[△]	2-heptanone	16.10	—	15	mesitylene	14.13	—
16[△p]	enanthal	16.27	—	16	carbolic acid	14.71	—
17[*△]	*o*-xylene	16.39	—	17[△p]	6-methyl-5-heptene-2-one	15.03	—
18	pyridine	16.69	0.02	18	*O*-ethyl-toluene,	15.66	0.16
19[p]	(*E*)-2-pentenal	17.46	0.21	19	1-(2-furyl)-1-propanone	16.65	—
20	(*E*)-2-hexenal	18.52	2.06	20	pseudocumene	17.6	0.06
21	hept-*trans*-4-enal	19.82	—	21[△p]	benzenemethanol	18.45	2.42
22[△]	1-pentanol	19.99	0.05	22[*△]	benzeneacetaldehyde	19.23	6.59
23[△]	3-octanone	20.36	—	23	4-ethyl-*o*-xylene	20.00	0.08
24	bicyclo [4.2.0] octa-1,3,5-triene	20.85	—	24[△]	methyl pyrrol-2-yl ketone	20.58	0.30
25	dihydro-2-methyl-3 (2*H*)-furanone	21.34	—	25	α-methyl-α-[4-methyl-3-pentenyl] oxiranemethanol	21.06	2.42
26	2-methyl-pyrimidine	21.54	—	26	2-ethyl-*p*-xylene	21.4	0.10
27[△]	2-octanone	22.37	—	27	*o*-cymene	21.53	0.20
28[△]	caprylic aldehyde	22.62	0.04	28	1-ethyl-*O*-xylene	22.05	0.27
29	cyclohexanone	23.06	0.05	29	*trans*-5-ethenyltetrahydro-α, α, 5-trimethyl-2-furanmethanol	22.23	1.25
30	2,2,6-trimethyl-cyclohexanone	24.43	0.06	30[*]	mequinol	22.49	0.12
31	3-methyl-2-buten-1-ol	24.72	0.07	31[*△p]	β-linalool	22.97	1.90
32	2-methyl-3-octanone	24.85	0.04	32[*△p]	hotrienol	23.39	0.72
33	(*E*)-2-heptenal	25.12	0.27	33	*m*-cymene	23.78	0.11
34[△]	6-methyl-5-hepten-2-one	25.81	0.57	34	2-methylbenzofuran	24.04	0.11
35[△]	pelargonic aldehyde	29.45	1.28	35[△]	durene	24.51	0.23
36	3,3,5-trimethyl-1,5-heptadiene	29.94	0.07	36	prehnitene	24.85	0.65
37	3,5,5-trimethyl-2-cyclohexen-1-one	30.12	—	37	3a,6a-dihydro-2(3*H*,4*H*)-cyclopenta [*b*] furanone	25.22	—
38	(*E*)-2-octenal	31.83	0.11	38	4-methyl indan	26.42	—
39	2,6,6-trimethyl-2-cyclohexene-1-carboxaldehyde	32.26	0.31	39	lilac aldehyde B	26.58	0.29
40	1,2,3,4-tetrahydro-1,1,7-trimethyl-naphthalene	32.51	—	40	lilac aldehyde A	27.31	—
41	acetic acid	33.11	0.06	41	1-butenyl benzene	27.39	—
42[△]	2-furancarboxaldehyde	34.39	3.87	42	isodurene	27.55	0.48
43[*]	α-lonene	34.72	0.47	43[△]	benzyl acetate	28.49	0.07
44[*p]	copaene	35.06	0.06	44	lilac aldehyde D	28.6	0.11
45	*cis*-tagetone	35.79	1.98	45	tetrahydro-2,2,6-trimethyl-6-vinyl-2*H*-pyran-3-ol	28.88	0.49
46	(*E*, *E*)-2,4-heptadienal	36.13	1.06	46	albocarbon	30.32	0.19
47	*trans*-tagetone	36.91	1.03	47	α-terpineol	30.79	0.46

(To be continued)

(Continued Table 1)

No.	Leaves			No.	Fruits		
	Compounds	t_R / min	RA / %		Compounds	t_R / min	RA / %
48△	benzaldehyde	38.07	4.02	48	1,5,6,7-tetramethylbicyclo [3.2.0] hepta-2, 6-diene	31.27	0.06
49	(*E*)-2-nonenal	38.37	0.06	49△	*n*-decaldehyde	31.76	0.08
50*△	β-linalool	38.73	0.05	50*	α-lonene	32.6	0.07
51	1,2,3,4-tetrahydro-1,1,5-trimethyl-naphthalene	39.16	—	51	α,4-dimethyl-3-cyclohexene-1-acetaldehyde	26.06	1.05
52△	1-octanol	39.50	0.47	52△	*cis*-geraniol	33.88	0.91
53	[1a*R*-(1aα,4α,4aβ,7bα)]-1a,2,3,4,4a,5,6,7b-octahydro-1,1,4,7-tetramethyl-1*H*-cycloprop[*e*]azulene	40.01	0.39	53	*p*-mentha-1(7), 8(10)-dien-9-ol	35.46	0.17
54	(*E*, *E*)-3,5-octadien-2-one	40.72	—	54△	*trans*-geraniol	36.02	0.33
55*p	5-methyl-2-furancarboxaldehyde	41.20	—	55△	(*E*)-2-decenal	36.71	0.18
56	4-cyclopentene-1,3-dione	42.02	0.11	56	(2*Z*)-2-phenyl-2-butenal	37.95	0.09
57	(*E*)-6-methyl-3, 5-heptadien-2-one	42.19	0.17	57	4-ethenyl-2-methoxy-phenol	41.5	0.16
58*△	hotrienol	42.63	0.52	58	α-cubebene	44.36	0.09
59	[1*S*-(1α,4α,7α)]-1,2,3,4,5,6,7,8-octahydro-1-4-dimethyl-7-(1-methylethenyl)-azulene	43.07	0.30	59	2,3-dihydro-1,1,5,6-tetramethyl-1*H*-indene	44.56	—
60	2,6,6-trimethyl-1-cyclohexene-1-carboxaldehyde	43.64	1.26	60	1,2-dihydro-2,5,8-trimethyl-naphthalene	44.87	0.05
61△	(*E*)-2-decenal	44.86	0.89	61	(*E*)-2-methoxy-5-propenyl-phenol	45.24	0.08
62	2,6,6-trimethyl-1,3-cyclohexadiene-1-carboxaldehyde	45.13	0.65	62*p	copaene	46.78	0.95
63*p	benzeneacetaldehyde	45.36	—	63*△	β-damascenone	47.44	0.41
64	[1*S*-(1α,7α,8aβ)]-1,2,3,5,6,7,8,8a-octahydro-1,4-dimethyl-7-(1-methylethenyl)-azulene	45.71	5.86	64*	[3a*S*-3aα,3bβ,4β,7α,7a*S**]-octahydro-7-methyl-3-methylene-4-[1-methylethyl]-1*H*-cyclopenta [1,3] cyclopropa [1,2] benzene	44.36	—
65△	2-methylbutyric acid	46.10	0.31	65	1, 1, 3-trimethyl-1*H*-indene	48.32	0.07
66	1,1,8-trimethyl-1,2,3,4-tetrahydro-naphthalene	47.42	0.28	66	3-(2,6,6-trimethyl-1-cyclohexen-1-yl)-2-propenal	48.62	—
67	*m*-*tert*-butyl-phenol	47.81	4.31	67	naphthalene, 1, 2, 3….	49.42	0.10
68*	[3a*S*-(3aα,3bβ,4β,7α)]-octahydro-7-methyl-3-methylene-4-(1-methylethyl)-1*H*-cyclopenta [1,3] cyclopropa [1,2] benzene	48.37	0.96	68	4-(2,6,6-trimethylcyclohexa-1,3-dienyl) butan-2-one	50.03	0.22
69	4,6,6-trimethyl-bicyclo [3.1.1] hept-3-en-2-one	48.93	1.31	69p	caryophyllene	50.53	0.10
70	1,2-dihydro-1,1,6-trimethyl-naphthalene	50.58	0.91	70	1,3-dimethylnaphthalene	50.75	0.06
71	3-ethyl-4-methyl-2,5-furandione	51.04	1.16	71*△	geranylacetone	52.91	0.12
72	(1-methoxyethyl)-benzene	51.37	1.57	72p	α-caryophyllene	53.33	—
73	methyl ethyl cyclopentene	51.79	—	73	aromadendrene	53.98	—
74	orcin	52.24	—	74	α-amorphene	55.14	0.07
75△p	methyl salicylate	52.94	0.45	75p	germacrene D	55.59	—
76	2,4-decadienal	54.50	—	76	*trans*-β-lonone	55.90	—
77	4-[2,6,6-trimethyl-1 (or 2)-cyclohexen-1-yl]-3-buten-1-one	54.62	—	77	α-(3-methylbutylidene)-benzeneacetaldehyde	56.21	0.20
78*△	β-damascenone	54.91	10.07	78	1. xi., 6. xi., 7. xi.-cadina-4,9-diene	57.08	0.06
79	caproic acid	55.97	—	79*	2,4-di-*tert*-butyl-phenol	57.82	0.08
80△	3-methyl-6-(1-methylethenyl)-2-cyclohexen-1-one	56.15	0.26	80	cadina-1(10),4-diene	58.89	2.20
81*△	geranylacetone	56.44	2.15	81	α-calacorene	60.61	0.82
82*	mequinol	57.17	0.51	82	4-[(2*E*)-2-butenyl]-1,2-dimethylbenzene	61.28	—

(To be continued)

(Continued Table 1)

No.	Leaves			No.	Fruits		
	Compounds	t_R / min	RA / %		Compounds	t_R / min	RA / %
83$^{\triangle p}$	benzyl alcohol	58.04	4.56	83	1*R*, *trans*-calamenene	66.44	0.57
84$^{\triangle p}$	β-ionone	60.91	1.14	84	9-methyl-1,2,3,4,5,6,7,8-octahydroanthracene	66.70	0.28
85$^{\triangle}$	enanthic acid	61.56	0.09	85$^{\triangle}$	diphenyl-methanone	67.29	0.13
86^{p}	eicosane	63.05	0.06	86	4-isopropyl-1,6-dimethyl-naphthalene	70.74	0.26
87$^{\triangle}$	octanoic acid	66.69	0.10	87$^{\triangle}$	myristaldehyde	73.06	0.62
88	heneicosane	67.87	0.21	88	methyl myristate	73.77	0.13
89	2,3-dihydro-1,1-dimethyl-1*H*-indene-4-carboxylic acid	68.51	0.11	89$^{\triangle}$	*n*-dodecanoic acid	76.99	0.05
90*	hexahydrofarnesyl acetone	69.71	2.46	90	9*H*-methylene-fluorene	78.29	0.09
91$^{\triangle}$	nonanoic acid	71.98	0.09	91	ethyl myristate	78.67	0.11
92	docosane	72.49	0.15	92$^{\triangle}$	palmitaldehyde	80.23	0.52
93	behenic acid	73.82	4.79	93*	hexahydrofarnesyl acetone	82.15	0.24
94	3-methoxy-2-naphthalenol	74.54	0.11	94$^{\triangle}$	myristic acid	82.85	—
95	arachyl alcohol	74.87	0.09	95	Ω-benzyl acetophenone	83.31	0.47
96^{p}	tricosane	77.02	1.23	96	14-pentadecenoic acid	82.64	0.35
97*	2,5-bis (1,1-dimethylethyl)-phenol	78.20	—	97*	diisobutyl phthalate	84.05	1.26
98	1-(2,3,6-trimethylphenyl)-3-buten-2-one	78.39	—	98	ethyl pentadecanoate	85.46	0.08
99	5,6,7,7a-tetrahydro-4,4,7a-trimethyl-2(4*H*)-benzofuranone	80.67	—	99$^{\triangle}$	methyl palmitate	87.58	1.49
100	(*E*,*E*)-6,10,14-trimethyl-5,9,13-pentadecatrien-2-one	80.82	1.16	100$^{*\triangle}$	dibutyl phthalate	90.3	1.69
101	tetracosane	81.26	0.66	101$^{\triangle}$	palmitic acid	91.57	15.74
102	1-(2,3,6-trimethylphenyl)-2-butanone	81.96	0.21	102	ethyl palmitate	92.10	8.84
103	(*E*)-3-(2-hydroxyphenyl)-2-propenoic acid	82.49	0.09	103*	methyl-(*Z*, *Z*)- 9,12-octadecadienoate	93.60	0.62
104^{p}	1-docosene	83.58	0.14	104*	linolenic acid methyl ester	98.71	1.45
105	indole	84.68	0.08	105	*cis*-9,*cis*-12-octadecadienoic acid	101.86	1.01
106^{p}	pentacosane	85.43	0.95	106$^{\triangle}$	ethyl linoleate	102.24	1.12
107*	methyl-(*Z*, *Z*)-9,12-octadecadienate	85.71	0.02	107	linolenic acid ethyl ester	102.76	1.67
108^{*p}	phthalic acid diisobutyl ester	88.10	1.39	108	*n*-heptacosane	109.97	0.29
109*	methyl linolenate	88.50	0.08				
110	[1a*R*-(1aα,7α,7aα,7bα)]-1a,2,3,5,6,7,7a,7b-octahydro-1,1,7,7a-tetramethyl-1*H*-cyclopropa [*a*] naphthalene	89.74	0.11				
111$^{\triangle p}$	phytol	90.50	1.97				
112$^{*\triangle}$	dibutyl phthalate	91.16	0.81				
113	17-pentatriacontene	91.57	0.66				
114	hexacosane	93.22	0.63				
115	butyl 2-methylpropyl-1,2-benzenedicarboxylate	94.15	2.05				
116	phenanthrene	96.23	0.45				
117^{p}	heptacosane	100.42	0.91				
118	octacosane	107.34	0.11				
119**	psoralen	117.25	10.12				
120	2*H*-furo [2,3-*H*]-1-benzopyran-2-one	117.68	—				
121^{**p}	bergapten	142.77	1.99				

*constituents in both leaves and fruits

**constituents confirmed by comparison with respective commercial standards

$^{\triangle}$aromatic constituents

^{p}previously reported

be a successfully developed method to identify and determine the essential oils in the leaves and fruits of *F. carica*. A total of 121 constituents have been identified in the leaves and 108 in the fruits. Eighteen constituents are shared in essential oils of the leaves and fruits.

Acknowledgements

The authors are grateful to Profs. YAO Ying-shan, A Bu Li Ke Mu, and LIU Jian-xin at Atushi Agricultural Bureau.

References

Ahmed W, Khan AQ, Malik A, 1988. Two triterpenes from the leaves of *Ficus carica*. *Planta Med* 54: 481.

Athnasios AK, El-kholy IE, Soliman G, Shaban MAM, 1962. Isolation of psoralen, bergapten, ψ-taraxasterol, and β-sistosterol from *Ficus carica. J Chem Soc* 62: 4253-4254.

Buttery RG, Flath RA, Mon TR, Ling LC, 1986. Identification of germacrene D in walnut and fig leaf volatiles. *J Agric Food Chem* 34: 820-822.

Canal JR, Torres MD, Romero A, Pérez C, 2000. A chloroform extract obtained from a decoction of *Ficus carica* leaves improves the cholesterolaemic status of rats with streptozotocin-induced diabetes. *Acta Physiol Hung* 87: 71-76.

Dominguez E, Canal JR, Torres MD, Campillo JE, Perez C, 1996. Hypolipidaemic activity of *Ficus carica* leaf extract in streptozotocin-diabetic rats. *Phytother Res* 10: 526-528.

Fujioka T, Furumi K, Fujii H, Okabe H, Mihashi K, Nakano Y, Mitsunaga H, Katano M, Mori M, 1999. Antiproliferative constituents from Umbelliferae plants. V. A new furanocoumarin and falcarindiol furanocoumarin ethers from the root of *Angelica japonica*. *Chem Pharm Bull* 47: 96-100.

Galhiane MS, Rissato SR, Chierice GO, Almeida MV, Silva LC, 2006. Influence of different extraction methods on the yield and linalool content of the extracts of *Eugenia uniflora* L. *Talanta* 70: 286-292.

Gibernau M, Buser HR, Frey JE, Mckey MH, 1997. Volatile compounds from extracts of figs of *Ficus carica*. *Phytochemistry* 46: 241-244.

Grison-Pigé L, Hossaert-McKey M, Greeff JM, Bessiére JM, 2002. Fig volatile compounds—a first comparative study. *Phytochemistry* 61: 61-71.

Hemmatzadeh F, Fatemi A, Amini F, 2003. Therapeutic effects of fig tree latex on bovine papillomatosis. *J Vet Med B Infect Dis Vet Public Health* 50: 473-476.

Knudsen JT, Tollsten L, Bergström LG, 1993. Floral scents—a checklist of volatile compounds isolated by head-space techniques. *Phytochemistry* 33: 253-280.

Matsuda H, Hirata N, Kawaguchi Y, Yamazaki M, Naruto S, Shibano M, Masahiko TI, Baba K, Kubo M, 2005. Melanogenesis stimulation in murine B16 melanoma cells by Umberiferae plant extracts and their coumarin constituents. *Biol Pharm Bull* 28: 1229-1233.

Okuyama T, Takata M, Takayasu J, Hasegawa T, Tokuda H, Nishino A, Nishino H, Iwashima A, 1991. Anti-tumor-promotion by principles obtained from *Angelica keiskei*. *Planta Med* 57: 242-246.

Oliveira AP, Silva LR, de Pinho PG, Gil-lzquierdo A, Valentao P, Silva BM, Pereira JA, Andrade PB, 2010. Volatile profiling of *Ficus carica* varieties by HS-SPME and GC-IT-MS. *Food Chem* 123: 548-557.

Park YR, Eun JS, Choi HJ, Nepal M, Kim DK, Seo SY, Li R, Moon WS, Cho NP, Bae TS, Kim BI, Soh Y, 2009. Hexane-soluble fraction of the common fig, *Ficus carica*, inhibits osteoclast differentiation in murine bone marrow-derived macrophages and RAW 264.7 cells. *Korean J Physiol Pharmacol* 13: 417-424.

Pérez C, Canal JR, Campillo JE, Romero A, Torres MD, 1999. Hypotriglyceridaemic activity of *Ficus carica* leaves in experimental hypertriglyceridaemic rats. *Phytother Res* 13: 188-191.

Pèrez C, Canal JR, Torres MD, 2003. Experimental diabetes treated with *Ficus carica* extract: Effect on oxidative stress parameters. *Acta Diabetol* 40: 3-8.

Pèrez C, Dominguez E, Ramiro JM, Campillo JE, 1992. Fitoterapia de la diabetes mellitus. EI efecto de las hojas de *Ficus carica* (Higuera). *Adv Diabetologia* 5: 71-80.

Pèrez C, Dominguez E, Ramiro JM, Romero A, Campillo JE, Torres MD, 1996. A study on the glycaemic balance in streptozotocin-diabetic rats treated with an aqueous extract of *Ficus carica* (Fig tree) leaves. *Phytother Res* 10: 82-83.

Ren DS, Duan XL, Abudu KD, 2000. Development and utilization of figs in Xinjiang. *Quarterly Forest By-Product Spec China* 53: 45-46.

Richter G, Schwarz HP, Dorner F, Turecek PL, 2002. Activation and inactivation of human factor X by proteases derived from *Ficus carica*. *Br J Haematol* 119: 1042-1051.

Rubnov S, Kashman Y, Rabinowitz R, Schlesinger M, Mechoulam R, 2001. Suppressors of cancer cell proliferation from fig (*Ficus carica*) resin: Isolation and structure elucidation. *J Nat Prod* 64: 993-996.

Saeed MA, Sabir AW, 2002. Irritant potential of triterpenoids from *Ficus carica* leaves. *Fitoterapia* 73: 417-420.

Serraclara A, Hawkins F, Pérez C, Domínguez E, Campillo JE, Torres MD, 1998. Hypoglycemic action of an oral fig-leaf decoction in type-I diabetic patients. *Diabetes Res Clin Pract* 39: 19-22.

Slavin JL, 2006. Figs: Past, present and future, nutrition. *Today* 41: 180-184.

Solomon A, Golubowicz S, Yablowicz Z, Grossman S, Bergman M, Gottlieb HE, Altman A, Kerem Z, Flaishman MA, 2006. Anti-oxidant activities and anthocyanin content of fresh fruits of common fig (*Ficus carica* L.). *J Agric Food Chem* 54: 7717-7723.

Sugiura M, Sasaki M, 1973. Studies on proteinases from *Ficus carica* var. *horaishi*. III. Stability of ficin A, B, C and D. *Yakugaku Zasshi* 93: 338-343.

Sugiura M, Sasaki M, 1974. Studies on proteinases from *Ficus carica* var. *horaishi*. V. Purification and properties of a sugar-containing proteinase (ficin S). *Biochim Biophys Acta* 350: 38-47.

Sugiura M, Sasaki M, Moriwaki C, Yamaguchi K, 1975. Studies on proteinases from *Ficus carica* var. *horaishi*. VI. Immunochemical comparison of ficins A, B, C, D and S. *Chem Pharm Bull* 23: 1969-1975.

Veberic R, Colaric M, Stampar F, 2008. Phenolic acids and flavonoids of fig fruit (*Ficus carica* L.) in the northern Mediterranean region. *Food Chem* 106: 153-157.

Wang G, Wang H, Song Y, Jia C, Wang Z, Xu H, 2004. Studies on anti-HSV effect of *Ficus carica* leaves. *J Chin Med Mater* 27: 754-756.

Yoo SW, Kim JS, Kang SS, Son KH, Chang HW, Kim HP, Bae K, Lee CO, 2002. Constituents of the fruits and leaves of *Euodia daniellii*. *Arch Pharmacal Res* 25: 824-830.

Zhao P, Zhou HM, Wu YJ, 2004. Studies on chemical constituents from leaves of *Ficus carica*. *Chin Tradit Herb Drugs* 35(12): 1341-1342.