

The Chemical Composition of the Leaf Essential Oils from 110 Citrus Species, Cultivars, Hybrids and Varieties of Chinese Origin^a

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China is one of the main countries in the world in which citrus species are cultivated. Today, the annual production of citrus fruit in China has reached about 10,000,000 tonnes. The chemical composition of citrus leaf oils of Chinese origin has not yet been systematically studied, although some specific species or varieties have been studied and reported.¹⁻⁶ We carried out systematic analytical studies on the composition of the leaf oils from 110 citrus species, varieties, hybrids and cultivars of Chinese origin in order to look for new resources for essential oils and provide the systematic chemical-composition data of the leaf oils for the taxonomy of citrus plants. In this article, we report the experimental results of this study.

Experiment

Analyses were carried out on 110 citrus species, varieties, hybrids and cultivars of Chinese origin. The citrus taxa studied were three species of *papeda*: *Citrus macroptera* Monter. (MAC), *C. hongheensis* Y.L. D.L. (HON) and *C. hystrix* D.C. (HYS); twelve species and cultivars of *Osmocitrus* (yuzu etc.), *C. junos* (Sieb.) Tan. cultivars: Xiecheng (JXI), Luohangcheng (JLU), Wangchangxiancheng (JWA), Mitaoxiancheng (JMI), Tangcheng (JTA), Nippon Xiancheng (JNX), Jiangbeixiancheng (JJI), Chanju (JCH) Zhencheng (JZH), and Bazhongxiancheng (JBA); *C. wilsonii* Tan cultivars: Zhejiangyuan (WZH) and Wangchangxianyuan (WWA); seventeen cultivars and one variety of *C. aurantium* L. (bitter orange), *C. aurantium* L. cultivars: African (AAF),

Brazilian (ABR), Spanish (ASP), Morocco (AMO), Italian (AIT), Bangan (ABA), Daidai (ADA), Xingshan (AXI), Bittersweet (ABS), Anti-Blight (AAB), Rubidoux (ARU), Australian (AAU), Guangpi (AGU), Zhulan (AZH), Goutou (AGO) and Jiangjin (AJI); *C. aurantium* var. *myrtifolia* Ker Gawl. (AMY), *C. taiwanica* Tan. ex Shimada (TAI); eleven cultivars and four hybrids of *C. sinensis* Osbeck (sweet orange), *C. sinensis* Osbeck cultivars: Taoyecheng (STA), Huangbaipitiancheng (SHU), Gailiangcheng (SGA), Jincheng (SJI), Hamlin (SHA), Washington (SWA), Ruby Blood (SRB), Valencia (SVA), Liucheng (SLI), Xuegan (SXU) and Xinhuicheng (SXI), *C. sinensis* x *C. reticulata* Blanco hybrids: (SIR), (SRE) and (SXR) and *C. sinensis* x *C. grandis* Osbeck (SGR); sixteen species and cultivars of *Citrophorum* (citron and lemon): *C. medica* L. (CME), *C. medica* var. *sarcodactylis* (Noot.) Swing. (MSA), *C. medica* var. *ethrog* Engl. (MET); *C. limon* Burm. f. cultivars: Eureka (LEU), Lisbon (LLI), Verna (LVE) and Botswana (LBO); *C. aurantifolia* Swing. cultivars: Mexico (AME), Tahiti (ATA) and Ponderosa (APO); *C. limonia* Osbeck var. *meyers lemon* Wong (LML), *C. limonia* Osbeck (LMN); *C. limonia* cultivar Honglimeng (LHO); *C. limettoides* Tan (LIM); *C. jambhiri* Lush. (JAM); *C. bergamia* Risso et Poit. (BER); sixteen species, cultivars and hybrids of *Cephalocitrus* (shaddock and grapefruit), *C. paradisi* Macf. cultivars: Marsh (PMA) and Duncan (PDU); *C. grandis* Osbeck cultivars: Shatianyou (GSH), Wubuhongxingyou (GWU), Chumenweidanyou (GCH), Xianluomiyou (GXI), Dianjiangbaiyou (GDI), Cuba (GCU), Jinxiangyou (GJI) and Madoumendanyou (GMA); *C. paradisi* x *C. tangerina* Hort. ex Tan. (PAT), *C. grandis* x *C. reticulata* hybrids

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(GRR) and (GRE); *C. limon* x *C. grandis* (LGR), *C. grandis* x *C. junos* (GRJ); *C. grandis* x *Poncirus trifoliata* Raf. (GPT); eighteen species, varieties and cultivars of *Microacrumen* (tangerine) *C. tangerina* cultivars: Chuanju (TCH), Dancy (TDA), and Fuju (TFU); *C. chuana* Hort. ex Tan. (CHU); *C. suhuiensis* Hort. ex Tan. (SUH); *C. ponki* Hort. ex Tan. (PON); *C. succosa* Hort. ex Tan. (SUC); *C. compressa* Tan. (COM); *C. tandiferax* Hort. ex Tan. (TAN); *C. chachiensis* Hort. ex Tan. (CHA); *C. sunki* Hort. ex Tan. (SUN); *C. reticulata* cultivars: Sihuishiyueju (RSI), Poonensis (RPO), Vietnamese (RVI), Jushaxianggan (RJu) and Daxianggan (RDA); *C. erythrosa* Hort. ex Tan. (ERY); *C. kinokuni* Hort. ex Tan. (KIN); *C. tachibana* Tan. (TAC), and eleven species and cultivars of *Macroacrumen* (mandarin), *C. clementina* Hort. ex Tan. (CLE); *C. suavissima* Hort. ex Tan. (SUA); *C. vessucosa* Hort. ex Tan. (VES); *C. nobilis* Lour. cultivars: Wanggan (NWA) and Bendiguanju (NBE); *C. unshiu* Marc. cultivar Wenzhang (UWE); *C. tankan* Hayata (TAK); *C. iyo* Hort. ex Tan. (IYO); *C. sulcata* Hort. ex Tan. (SUL); *C. hassaku* Hort. ex Tan. (HAS), and *C. madurensis* Lour. (MAD).

The authors gathered all leaf samples studied in this work from authentic trees cultivated in the citrus botanical garden of the Citrus Research Institute, Chinese Academy of Agricultural Sciences, in the autumnal periods of 1990-1994. They were carefully selected to avoid contamination with leaf materials of other species.

Leaf oils were obtained in our laboratory by steam distillation using an all-glass distillation apparatus. They were analyzed by GC using a Sigma 2000 (FID) gas-chromatograph fitted with an OV-101 column 50m x 0.25mm and an OV-17 column 50m x 0.25mm and by GC/MS using DANI 380-VG7070E mass spectrometer.

Component identification was made by comparing dual-column retention times of the components with those of reference compounds on the above-mentioned two columns, and by comparing the mass spectra of the components with those of the Adams Library.⁷ The quantitative composition was calculated as a relative percentage of the peak area for each component.

For comparison purposes, great attention was paid to keep the experimental method, conditions and equipment in the experimental process consistent throughout the study.

Results and Discussion

The results of the many analyses are listed in the Tables 1-7, respectively. The compounds are listed in each table in order of elution from and OV-101 column. It should be noted that co-elution on the OV-101 occurred with limonene, 1,8-cineole, β -phellandrene and (Z)- β -ocimene, neryl acetate and δ -elemene, and germacrene B and valencene. As a result, they were separated, identified and quantified on an OV-17 column.

Table 1 shows the quantitative composition of leaf oils from three species of the *Papeda* section (A) and twelve

species and cultivars of the *Osmocitrus* section (B) within the citrus genus. Among them can be found *C. hongheensis*, which is a new species found in Yunnan province. *C. hystrix* was found to contain citronellal (77.98%) in its leaf oil, *C. junos* (Sieb.) Tan cv. Xieheng and *C. junos* (Sieb.) Tan cv. Luohancheng contain 64.14% and 63.57% methyl N-methyl anthranilate in their leaf oils, respectively. These latter cultivars of *C. junos* are valuable plant resources for methyl N-methyl anthranilate-rich essential oils. Leaf oils from the other ten cultivars of *C. junos* and two cultivars of *C. wilsonii* contained it only in small amounts. They are examples of other chemotypes.

A survey of citrus literature reveals that methyl N-methyl anthranilate is a main component of mandarin leaf oils.^{8,9} In our studies, methyl N-methyl anthranilate was not detected or was detected only in small amounts in the leaf oils from thirty species and cultivars of tangerine (Table 6) and mandarin (Table 7), but existed in large quantities in two of the leaf oils from *C. junos* as described above. This finding may be due to the different views on the classification and identification of citrus species.

Table 2 shows the analytical results of the leaf oils from seventeen cultivars and one variety of *C. aurantium* L. According to the chemical composition of their leaf oils, eighteen cultivars can be divided into two groups. The first group (A), including twelve cultivars, was rich in linalool (31.93-39.75%) and linalyl acetate (24.18-34.74%). The second group (B), including six cultivars, contained no linalyl acetate or linalool, but contained different monoterpene hydrocarbons as the main components, such as sabinene (54.39-55.10%) and (E)- β -ocimene (18.55-18.57%) in *C. aurantium* L. cv. Australian and cv. Guanpi, or β -pinene (48.77-49.78%) and (E)- β -ocimene (6.14-11.46%) in *C. aurantium* L. cv. Jiangjin and *C. taiwanica*, or γ -terpinene (33.90%) in *C. aurantium* L. cv. Zhulian. From a commercial standpoint, the leaf oils of the group (A) are of more interest because of their higher content of linalyl acetate and linalool.

Table 3 shows the chemical composition of the leaf oils from *C. sinensis* Osbeck. With the exception of four hybrids (B), the leaf oils from eleven cultivars of *C. sinensis* (A) all possessed roughly the same chemical composition with their main components being sabinene (30.19-52.11%) and δ -3-carene (2.87-10.27%).

Table 4 shows the chemical composition of the leaf oils from the *Citrophorum* section within the citrus genus (citron and lemon). The leaf oils of nine species and cultivars of the group (A) all possessed similar compositions with their major components being limonene (20.52-46.82%) and citral (neral + geranial) (28.15-43.97%). The leaf oils of another group (C), including *C. limonia* Osbeck and cv. Honglimeng, contained mainly β -pinene (26.24-27.86%), limonene (23.29-24.08%) and citronellal (15.27-15.73%). The composition of the leaf oils from *C. bergamia* (D) was similar to the leaf oils from *C. aurantium*, which were rich in linalyl acetate and linalool. This suggests that

C. bergamia is a close relative to *C. aurantium*. The remaining four cultivars in Table 5 form group B. Their leaf oils possessed a different composition to each other.

Table 5 shows the analytical results of the leaf oils from sixteen species, cultivars and hybrids of the *Cephalocitrus* section within the citrus genus (shaddock and grapefruit). According to the composition of leaf oils, the sixteen species, cultivars and hybrids may be classified into three groups. Group A includes two cultivars of *C. paradisi*, (cv. Marsh and cv. Duncan). Their leaf oils contained mainly sabinene (50.38-50.57%), (E)- β -ocimene (9.23-10.47%) and linalool (8.18-8.51%). The five cultivars of *C. grandis* form group B. Their leaf oils possessed approximately the same composition with β -pinene (34.29-46.31%) and (E)- β -ocimene (12.82-26.23%) as main components. Group C consisted of nine hybrids and mutations. The compositions of their leaf oils were different from above-listed species, hybrids and cultivars and were also different from each other.

Tables 6 and 7 show the quantitative composition of the leaf oils from thirty species and cultivars of the *Acrumen* section of the citrus genus (tangerine and mandarin). The taxonomy of the *Acrumen* section is a complex problem because the views of many phytotaxonomists are divergent. The focus lies in so-called "big species" or "small species". Swingle¹⁰ regarded *Acrumen* as a species, e.g. *Citrus reticulata* Blanco., but Tanaka¹¹ classified the *Acrumen* section into thirty-six species. Chinese phytotaxonomists generally divide *Acrumen* into the following two subsections: *Microacrumen* (tangerine) and *Macroacrumen* (mandarin). Numerous morphological differences exist between tangerine and mandarin. Generally speaking, tangerine is characterized by the possession of small flowers, small fruit and a thin, smooth and red peel, but mandarin is characterized by the possession of large flowers and fruit with a thick, rough and yellow peel. In this study, nineteen species and varieties belong to tangerine, ten species and varieties to mandarin were examined. Other species, such as *C. madurensis*, may be a hybrid between tangerine and *Fortunella* sp. According to composition of the leaf oils, the nineteen species and cultivars in Table 6 are considered to belong to *Microacrumen* (tangerine) and can be classified into five groups. Group A includes three varieties of *C. tangerina*, the leaf oils of which possessed a similar composition and were characterized by the presence of large amounts of thymol (6.67-7.48%) and thymol methyl ether (7.43-9.10%). Group B includes three species: *C. chuana*, *C. suhuiensis* and *C. ponki*, the leaf oils of which contained linalool (32.52-46.77%), γ -terpinene (13.68-16.64%) and thymol (10.24-15.14%). Group C includes the leaf oils of *C. succosa*, *C. compressa* and *C. tandiferax*, which were found to contain linalool (38.17-43.74%), γ -terpinene (13.01-16.09%) and p-cymene (9.66-16.10%) as main components. Group D includes *C. chachiensis*, *C. sunki* and five cultivars of *C. reticulata*. The leaf oils of this subgroup possess similar compositions with their major components

being sabinene (34.49-59.85%) and linalool (10.61-32.63%). *C. erythrosa*, *C. kinokuni* and *C. tachibana* form Group E. The composition of their leaf oils were dissimilar to the species and cultivars of the above-listed four subgroups. In addition, they were also dissimilar to each other.

In contrast with the *Microacrumen* leaf oils, the leaf oils from ten species and cultivars of *Macroacrumen* in Table 7 are considered to belong to the mandarin group, all possessing differing compositions. Such differences reveal that, among these cultivars of mandarin, a wide variation in composition exists.

From a commercial standpoint, among the species and cultivars of mandarin studies, *C. tankan* is of interest because its leaf oil contained linalool (63.46%) while its fruit had a fine quality. As a result, *C. tankan* could be considered as a valuable species whether it is used as an essential oil resource or as a fruit.

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Table 1. Chemical composition (%) of citrus leaf oils from papeda and osmocitrus

Grouping	MAC	HON	HYS	JXI	JLU	JWA	JMI	JTX	JNX	JJI	JLH	JZH	JBA	WZH	WWA
Compound	A	A	A	B	B	B	B	B	B	B	B	B	B	B	B
α -thujene	0.15	tr.	0.02	0.31	0.21	2.15	1.76	2.12	1.99	2.19	2.03	1.81	1.13	0.74	1.11
α -pinene	1.29	0.10	0.10	0.84	0.56	5.12	4.45	5.59	4.12	4.50	4.02	4.40	3.00	1.86	3.1
camphene	0.03	tr.	tr.	tr.	tr.	0.05	0.05	0.06	0.07	0.05	0.04	0.04	0.07	0.04	0.06
6-methyl-5-hepten-2-one	0.31	-	-	0.03	tr.	-	-	-	-	-	-	-	0.07	tr.	0.12
sabinene	20.89	0.06	2.42	0.20	0.21	0.94	1.05	0.07	2.76	0.65	0.69	0.97	1.65	1.44	1.41
β -pinene	0.94	0.13	0.17	0.85	0.76	4.59	4.08	5.50	11.48	4.91	4.66	3.98	12.50	8.00	9.81
myrcene	1.90	3.16	0.72	0.54	0.46	1.67	1.83	1.83	1.15	1.39	1.36	1.61	1.06	0.64	1.20
α -phellandrene	1.87	tr.	tr.	0.27	0.21	1.41	1.77	0.68	0.09	0.37	0.54	1.60	0.33	0.04	0.16
δ -3-carene	0.03	tr.	0.04	-	-	-	-	-	-	-	-	-	0.02	-	0.03
α -terpinene	0.18	0.05	0.04	0.11	0.06	0.81	0.77	0.33	0.77	1.08	0.89	0.67	0.19	0.19	0.14
p-cymene	0.29	0.03	tr.	2.77	1.16	11.45	12.12	12.84	3.72	6.77	11.02	6.93	11.98	4.50	14.55
limonene	5.35	23.48	0.12	12.42	9.87	5.15	7.53	5.08	4.32	5.68	7.78	6.12	3.29	2.12	2.95
1,8-cineole	0.02	0.03	-	tr.	tr.	tr.	tr.	-	0.18	-	-	-	-	0.07	-
(Z)- β -ocimene	0.22	0.10	0.05	0.16	0.30	0.20	0.23	0.12	0.23	0.14	0.09	0.08	0.10	0.27	0.10
β -phellandrene	9.13	0.05	0.03	2.36	0.68	8.98	12.02	8.20	0.17	2.08	4.04	14.66	4.78	0.15	2.60
(E)- β -ocimene	8.02	0.80	0.35	2.33	2.90	4.36	4.57	5.87	4.94	3.93	3.72	2.69	2.61	6.87	2.79
γ -terpinene	0.41	tr.	0.07	9.12	11.19	25.68	26.03	26.64	50.54	53.23	50.93	47.99	22.56	12.88	25.36
octanol	0.04	0.03	0.06	0.02	tr.	-	-	-	0.04	-	-	-	0.02	tr.	0.03
cis-sabinene hydrate	0.40	0.22	0.09	0.03	tr.	0.04	0.04	0.05	0.04	0.03	tr.	-	0.03	0.03	0.04
cis-linalool oxide	0.18	0.32	0.33	0.10	0.06	-	-	-	0.02	-	-	-	0.02	0.04	0.07
α -p-dimethylstyrene	-	-	-	0.41	0.04	8.49	7.01	9.56	0.03	0.03	-	0.03	0.02	1.08	0.02
terpinolene	0.14	0.03	0.05	0.41	0.31	2.52	2.52	2.09	1.87	2.54	2.22	2.12	0.89	0.90	0.86
nonanal	0.06	0.09	0.17	tr.	0.02	-	-	-	-	-	-	-	tr.	-	0.06
linalool	1.15	0.83	3.66	0.17	0.22	8.14	5.80	5.75	5.50	7.85	3.33	0.07	2.83	38.16	1.89
isopulegol	0.04	0.33	-	-	-	0.89	0.78	0.52	-	-	-	-	0.02	0.26	-
citronellal	2.19	33.28	77.98	-	-	0.09	0.06	0.06	0.51	0.02	0.02	0.03	2.31	0.61	1.35
terpinen-4-ol	0.79	0.05	0.05	0.07	0.06	0.14	0.12	0.06	0.19	0.16	0.06	0.13	0.12	0.12	0.32
α -terpineol	0.54	0.13	0.02	0.13	0.05	0.09	0.10	0.06	0.08	0.17	0.02	0.02	0.34	0.17	0.24
decanal	0.29	0.65	0.16	0.12	0.12	0.04	0.06	0.05	0.02	-	-	-	0.27	0.04	0.04
citronellol	0.37	3.56	5.99	-	-	-	-	-	0.13	tr.	0.02	-	0.43	0.28	1.54
nerol	1.90	0.58	0.04	-	-	0.05	0.05	0.02	0.41	0.04	0.02	-	1.02	0.19	5.84
thymol methyl ether	0.05	-	-	-	-	0.17	0.11	0.04	0.02	-	-	-	-	-	-
neral	6.77	1.78	tr.	-	-	0.02	-	-	0.08	0.03	tr.	-	2.79	0.30	1.21
geraniol	3.66	4.10	0.12	-	-	0.03	0.03	0.03	0.02	0.02	tr.	-	0.17	0.11	0.82
geranial	8.68	2.85	0.05	tr.	-	tr.	-	tr.	0.11	0.02	tr.	-	3.68	0.33	1.43
thymol	0.05	0.12	-	0.62	0.03	1.08	1.19	0.34	tr.	-	-	0.06	0.08	9.77	0.20
undecanal	0.02	0.07	tr.	0.07	0.08	-	-	-	tr.	-	-	-	-	0.06	-
methyl geranate	0.05	-	-	-	-	-	-	-	tr.	-	-	-	0.06	-	0.17
citronellyl acetate	0.27	3.21	3.75	tr.	0.03	tr.	tr.	tr.	0.13	-	-	-	1.27	0.06	2.69
neryl acetate	3.58	1.16	0.13	tr.	0.07	tr.	tr.	tr.	1.68	0.02	tr.	tr.	12.60	0.22	12.46
δ -elemene	-	-	0.05	0.03	0.09	0.15	0.10	0.09	-	-	-	-	-	0.80	-
geranyl acetate	13.53	14.33	0.75	tr.	0.02	tr.	tr.	tr.	0.04	tr.	tr.	0.04	1.86	0.23	1.32
methyl N-methyl anthranilate	-	-	-	64.00	63.57	-	-	-	-	-	-	0.35	-	-	-
β -elemene	0.51	-	-	0.08	0.40	0.09	0.04	0.04	tr.	0.02	tr.	0.22	0.03	1.50	0.17
β -caryophyllene	0.26	0.17	0.15	0.04	0.37	0.91	0.37	0.74	0.40	0.04	0.06	0.35	0.24	0.68	0.74
(Z)- β -farnesene	0.30	-	-	0.10	0.06	0.34	0.27	0.28	0.06	0.04	0.03	0.14	0.09	-	0.20
α -humulene	0.15	0.03	0.04	0.02	0.09	0.13	0.06	0.15	0.06	tr.	tr.	0.11	0.05	0.44	0.13
γ -muurolene	0.02	-	-	0.04	0.11	0.19	0.10	0.12	0.02	0.03	0.02	0.02	0.03	0.02	-

Table 1. Chemical composition (%) of citrus leaf oils from papeda and osmocitrus (*continued*)

	MAC	HON	HYS	JXI	JLU	JWA	JMI	JTX	JNX	JJI	JLH	JZH	JBA	WZH	WWA
Grouping	A	A	A	B	B	B	B	B	B	B	B	B	B	B	B
Compound															
(E,E)- α -farnesene	0.03	0.09	0.04	0.04	tr.	-	-	-	0.03	0.13	0.12	-	0.05	tr.	-
germacrene B	0.27	0.04	0.07	0.04	tr.	0.60	0.17	0.24	0.17	0.05	0.07	0.02	0.19	0.14	0.11
δ -cadinene	0.11	0.02	0.06	tr.	-	0.16	0.08	0.11	0.09	tr.	0.02	-	0.08	-	0.12
elemol	0.06	-	0.09	0.02	0.09	-	-	-	0.06	-	-	-	-	-	-
(E)-nerolidol	0.06	0.26	0.42	0.04	0.34	0.07	0.07	0.22	0.33	0.05	0.05	-	0.22	0.21	0.26
spathulenol	0.25	0.16	0.04	0.03	tr.	0.24	0.17	0.25	0.19	tr.	-	-	0.11	0.33	-
caryophyllene oxide	0.09	0.10	0.09	0.03	0.08	0.03	0.03	0.05	0.06	-	-	-	0.05	0.06	*
β -eudesmol	0.09	-	-	0.04	0.22	0.15	0.12	0.13	0.10	-	-	-	0.11	-	-
β -sinensal	-	-	-	-	-	-	-	-	-	0.26	0.15	1.04	-	-	-
α -sinensal	-	-	-	-	-	-	-	-	-	-	1.10	0.72	tr.	-	-
Total	97.98	96.58	98.58	99.01	95.10	97.41	97.71	95.98	99.02	98.52	99.12	99.02	97.42	96.95	99.85

tr. = <0.02%

MAC = *C. macroptera*; HON = *C. hongheensis*; HYS = *C. hysrix*; JXI = *C. junos* cv. Xiecheng; JLU = *C. junos* cv. Luohancheng; JWA = *C. junos* cv. Wangchangxiancheng; JMI = *C. junos* cv. Mitaoxiancheng; JTA = *C. junos* cv. Tangcheng; JNX = *C. junos* cv. Nippon Xiancheng; JJI = *C. junos* cv. Jiangbeixiancheng; JCH = *C. junos* cv. Chanju; JZH = *C. junos* cv. Zhencheng; JBA = *C. junos* cv. Bazhongxiancheng; WZH = *C. wilsonii* cv. Zhejiangyuan; WWA = *C. wilsonii* cv. Wangchangxianyuan

Table 2. Chemical composition (%) of citrus leaf oils from *C. aurantium*

	AAF	AMY	ABR	ASP	AMO	AIT	ABA	ADA	AXI	ABS	AAB	ABU	AAU	AGU	AZH	AGO	AJI	TAI
Grouping	A	A	A	A	A	A	A	A	A	A	A	A	B	B	B	B	B	B
Compound																		
α -thujene	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	0.02	tr.	tr.	tr.	0.48	0.45	1.82	0.43	0.14	0.20
α -pinene	0.14	0.08	0.10	0.13	1.08	0.12	0.12	0.10	0.11	0.12	0.15	0.20	2.08	2.15	4.04	2.14	3.04	2.09
camphene	tr.	tr.	tr.	tr.	0.03	tr.	tr.	tr.	tr.	tr.	tr.	tr.	0.07	0.07	0.05	0.16	0.19	0.25
sabinene	0.35	0.24	0.26	0.34	0.32	0.33	0.35	0.26	1.70	0.32	0.37	0.49	55.10	54.39	1.34	5.25	8.15	9.65
β -pinene	1.96	1.61	1.37	1.87	1.88	1.79	1.96	1.26	0.78	1.87	2.27	2.95	4.37	4.91	7.79	26.56	49.78	48.77
myrcene	2.21	2.32	2.06	2.18	2.52	2.65	2.23	2.52	2.49	2.12	2.21	2.48	3.06	3.04	1.08	1.18	0.48	0.99
α -phellandrene	tr.	tr.	tr.	tr.	tr.	tr.	tr.	-	-	-	-	-	0.11	0.12	0.07	0.09	-	0.19
δ -3-carene	0.05	0.05	0.10	0.04	tr.	0.02	tr.	tr.	0.38	0.03	0.02	tr.	0.21	0.65	-	3.12	tr.	2.96
α -terpinene	0.03	0.03	0.03	0.03	0.02	0.02	tr.	0.02	0.06	0.03	0.03	0.04	0.73	0.62	0.42	0.35	0.07	0.13
p-cymene	tr.	tr.	0.03	tr.	tr.	tr.	0.02	-	0.02	tr.	tr.	tr.	0.10	0.13	8.62	5.24	0.04	0.08
limonene	0.56	0.65	0.54	0.53	0.56	0.62	0.58	0.58	0.68	0.57	0.53	0.61	1.92	1.85	4.42	6.90	2.61	4.78
1,8-cineole	tr.	tr.	tr.	tr.	-	-	-	-	-	-	-	-	-	-	-	1.13	-	0.57
(Z)- β -ocimene	0.92	0.98	0.95	0.92	0.86	0.96	0.79	0.87	0.87	0.89	0.91	1.03	0.59	0.53	0.08	0.17	0.30	0.19
β -phellandrene	0.04	0.03	0.04	0.05	0.04	0.04	0.04	0.03	0.06	0.04	0.05	0.06	0.72	0.75	0.09	0.52	0.94	0.92
(E)- β -ocimene	2.51	2.54	2.34	2.45	2.41	2.54	2.52	2.28	2.52	2.48	2.60	2.91	18.55	18.57	1.55	4.67	11.46	6.14
γ -terpinene	0.04	0.05	0.04	0.04	0.04	0.05	0.03	0.03	0.10	0.04	0.04	0.05	1.31	1.15	39.90	6.57	0.18	0.23
octanol	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	-	tr.	0.03	0.03	0.03	0.03	0.04	-
cis-sabinene hydrate	0.03	0.05	0.04	0.04	0.02	0.02	0.03	0.02	0.04	0.03	0.03	0.04	0.43	0.34	tr.	0.04	tr.	0.12
cis-linalool oxide	0.03	0.04	0.04	0.12	0.07	0.04	0.06	0.05	0.05	0.03	0.03	0.05	0.03	0.03	tr.	0.05	0.06	0.08
α -p-dimethylstyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.49	-	-	-
terpinolene	0.48	0.51	0.45	0.46	0.44	0.48	0.36	0.44	0.52	0.44	0.45	0.51	0.33	0.34	1.77	0.67	0.08	0.53

Continued on next page

Table 2. Chemical composition (%) of citrus leaf oils from *C. aurantium* (continued)

Grouping	AAF	AMY	ABR	ASP	AMO	AIT	ABA	ADA	AXI	ABS	AAB	ABU	AAU	AGU	AZH	AGO	AJI	TAI
Compound	A	A	A	A	A	A	A	A	A	A	A	A	B	B	B	B	B	B
nonanal	0.04	0.05	0.06	0.14	0.04	0.03	0.03	0.03	0.05	0.03	0.04	0.05	0.23	0.18	-	0.08	tr.	tr.
linalool	35.11	37.73	36.78	32.45	33.91	36.75	35.71	39.75	34.52	34.58	33.49	31.93	0.42	0.42	9.75	10.70	1.52	0.40
isopulegol	tr.	tr.	tr.	tr.	tr.	tr.	tr.	0.02	tr.	tr.	tr.	tr.	0.07	0.06	0.39	-	-	-
citronellal	0.06	0.06	0.17	0.08	0.05	0.12	0.06	0.05	0.30	0.09	0.07	0.03	0.06	0.09	0.60	4.15	0.89	1.03
terpinen-4-ol	0.08	0.10	0.09	0.09	0.13	0.12	0.10	0.11	0.28	0.09	0.09	0.10	2.33	1.94	0.15	0.41	0.29	0.36
α -terpineol	8.17	9.77	7.73	7.75	10.27	10.39	8.52	9.91	10.03	7.72	7.42	8.57	0.15	0.10	0.08	0.85	0.08	0.34
decanal	-	-	-	-	-	-	-	-	-	-	-	-	0.06	0.06	tr.	-	0.03	0.04
citronellol	0.02	0.03	0.07	0.03	0.05	0.05	0.04	0.05	0.09	0.03	0.04	tr.	0.04	0.03	0.20	0.87	0.41	0.26
nerol	1.71	1.99	1.74	1.65	1.82	1.86	1.52	1.73	1.80	1.67	1.58	1.75	0.06	0.07	0.14	0.59	0.08	0.40
neral	0.14	0.10	0.31	0.14	0.04	0.09	0.06	0.05	0.28	0.13	0.13	0.05	0.02	0.02	0.05	2.37	tr.	1.98
geraniol	4.47	5.49	4.21	4.22	5.95	6.09	5.04	5.46	5.81	4.35	4.00	4.74	0.05	0.06	0.05	0.68	tr.	0.36
linalyl acetate	31.73	26.07	31.25	34.74	27.46	24.18	30.24	24.75	26.48	33.64	34.14	31.01	-	-	-	-	-	-
geranial	0.11	0.06	0.29	0.12	0.06	0.11	0.10	0.05	0.34	0.10	0.07	0.05	0.04	0.04	0.14	3.50	tr.	2.88
thymol	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	8.13	-	tr.	0.02
undecanal	0.06	0.05	0.03	0.07	tr.	0.08	0.05	0.03	tr.	0.07	0.06	0.06	-	-	0.04	-	0.07	0.03
methyl geranate	tr.	tr.	0.02	tr.	tr.	tr.	0.02	tr.	0.04	tr.	tr.	tr.	-	-	-	-	-	-
citronellyl acetate	0.06	0.05	0.04	0.05	0.04	0.09	0.03	0.05	0.08	0.04	0.05	0.05	0.04	0.07	0.13	0.66	0.45	0.34
α -terpinyl acetate	0.09	0.12	0.09	0.10	0.09	0.09	0.09	0.09	0.08	0.09	0.09	0.11	-	-	-	0.18	-	-
neryl acetate	2.41	2.90	2.50	2.47	2.86	3.10	2.52	2.81	2.91	2.35	2.33	2.58	0.54	0.61	0.23	0.95	0.72	1.62
δ -elemene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.89	0.39
geranyl acetate	4.59	5.39	5.03	4.75	5.18	5.64	4.68	5.12	5.19	4.65	4.36	4.76	0.06	0.07	0.03	2.64	-	2.16
β -elemene	tr.	tr.	tr.	tr.	tr.	tr.	tr.	tr.	0.04	tr.	tr.	tr.	0.03	0.03	0.02	0.05	0.75	0.16
β -caryophyllene	0.35	0.17	0.27	0.48	0.17	0.22	0.50	0.16	0.14	0.27	0.53	0.40	0.84	0.76	0.22	0.45	2.80	1.01
(Z)- β -farnesene	0.02	0.02	0.02	0.02	tr.	0.02	tr.	-	-	0.02	0.03	tr.	-	-	0.67	-	0.35	-
α -humulene	0.04	0.06	0.04	0.06	0.03	0.04	0.07	0.02	0.02	0.03	0.06	0.05	0.11	0.10	0.06	0.15	0.68	0.18
(E,E)- α -farnesene	0.02	0.02	0.03	0.03	0.02	0.02	tr.	tr.	tr.	tr.	0.03	0.02	0.04	0.11	-	-	1.24	0.12
germacrene B	0.13	0.06	0.13	0.18	0.06	0.09	0.21	0.08	0.06	0.10	0.18	0.12	0.34	0.29	0.12	0.24	1.17	0.16
valencene	-	-	-	-	-	-	-	-	-	-	-	-	0.52	0.49	-	-	-	-
δ -cadinene	0.04	0.02	0.03	0.04	0.02	0.02	0.03	0.03	0.02	0.03	0.04	0.03	0.09	0.07	0.04	0.04	0.49	0.09
elemol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.08	-	1.91	0.55
(E)-nerolidol	0.11	0.09	0.09	0.12	0.09	0.08	0.12	0.09	0.07	0.14	0.16	0.15	0.02	0.03	0.28	0.39	3.98	1.47
spathulenol	0.05	0.05	0.02	0.06	0.04	0.04	0.04	0.05	0.03	0.03	0.03	0.06	0.26	0.33	0.26	0.41	0.81	0.25
caryophyllene oxide	0.06	0.08	0.03	0.06	0.08	0.08	0.08	0.09	0.05	0.07	0.08	0.13	0.38	0.43	0.10	0.19	0.78	0.20
Total	99.02	99.71	99.46	99.10	98.75	99.08	98.95	99.04	99.11	99.33	98.79	98.22	97.02	160.93	96.52	95.82	97.95	95.67

tr.- <0.02%

AAF = *C. aurantium* cv. African; AMY = *C. aurantium* var. *myrtifolia*; ABR = *C. aurantium* cv. Brazilian; ASP = *C. aurantium* cv. Spanish; AMO = *C. aurantium* cv. Morocco;AIT = *C. aurantium* cv. Italian; ABA = *C. aurantium* cv. Banggan; ADA = *C. aurantium* cv. Daidai; AXI = *C. aurantium* cv. Xingshan; ABS = *C. aurantium* cv. Bitter Sweet;AAB = *C. aurantium* cv. Anti-Blight; ARU = *C. aurantium* cv. Rubidoux; AAU = *C. aurantium* cv. Australian; AGU = *C. aurantium* cv. Guangpi; AZH = *C. aurantium* cv. Zhulan;AGO = *C. aurantium* cv. Goutou; AJI = *C. aurantium* cv. Jiangjin; TAI = *C. taiwanica*

Table 3. Chemical composition (%) of citrus leaf oils from *C. sinensis*

Grouping	STA	SHU	SGA	SJI	SHA	SWA	SRB	SVA	SLI	SXU	SXI	SIR	SRE	SGR	SXR
Compound	A	A	A	A	A	A	A	A	A	A	A	B	B	B	B
(E)-2-hexenal	0.24	-	-	0.06	0.04	0.11	-	0.12	-	-	-	0.16	-	-	-
(Z)-3-hexenol	0.03	-	-	tr.	0.02	0.02	-	0.02	-	tr.	tr.	0.05	tr.	tr.	tr.
α -thujene	0.29	0.28	0.36	0.31	0.33	0.26	0.31	0.33	0.44	0.40	0.41	0.24	0.29	0.06	0.43
α -pinene	1.40	1.46	1.77	1.35	1.74	1.39	1.58	1.55	1.85	1.92	1.67	1.17	1.51	0.95	1.93
camphene	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.05	0.05	0.03	0.04	0.09	0.05
6-methyl-5-hepten-2-one	0.52	0.50	0.44	0.52	0.31	0.50	0.35	0.36	0.23	0.17	0.24	0.27	0.42	0.08	tr.
sabinene	30.19	33.65	42.05	34.49	39.37	34.92	35.26	35.66	49.38	52.11	45.33	27.41	33.53	2.73	48.95
β -pinene	1.40	1.51	1.98	1.72	1.87	1.63	1.71	1.63	2.25	2.40	2.11	1.31	1.58	15.69	2.58
myrcene	3.81	3.59	3.84	3.77	4.23	3.59	3.61	3.83	4.07	3.65	3.76	2.97	3.70	22.97	3.19
α -phellandrene	0.73	0.54	0.43	0.43	0.61	0.52	0.48	0.56	0.46	0.23	0.31	0.44	0.54	tr.	0.09
δ -3-carene	10.27	7.99	6.23	7.29	7.44	7.25	7.79	8.24	5.65	2.87	5.50	6.33	7.83	tr.	0.02
α -terpinene	0.43	0.28	0.41	0.13	0.40	0.34	0.40	0.45	0.59	0.66	0.57	0.32	0.37	0.02	0.38
p-cymene	0.16	0.11	0.16	0.83	0.07	0.11	0.17	0.12	0.14	0.09	0.23	0.07	0.10	0.06	0.63
limonene	5.13	5.67	4.51	3.42	7.15	3.39	9.48	4.16	3.42	2.62	3.69	1.96	5.88	1.24	2.72
(Z)- β -ocimene	0.34	0.20	0.24	0.19	0.27	0.24	0.25	0.27	0.22	0.21	0.21	0.29	0.29	0.24	0.24
β -phellandrene	0.86	0.77	0.81	0.52	0.82	0.75	0.79	0.81	0.92	0.81	0.86	0.50	0.76	0.37	0.52
(E)- β -ocimene	10.16	6.07	7.00	4.99	7.64	7.30	6.86	7.99	6.48	6.42	5.74	7.31	8.29	6.86	5.02
γ -terpinene	0.59	0.45	0.73	0.34	0.61	0.54	0.71	0.73	1.05	1.19	1.11	0.50	0.62	0.10	2.17
cis-sabinene hydrate	0.48	0.45	0.28	0.99	0.37	0.44	0.32	0.38	0.39	0.56	0.47	0.67	0.37	0.04	0.53
cis-linalool oxide	0.32	0.23	0.15	0.16	0.27	0.23	0.18	0.23	0.17	0.09	0.15	0.24	0.24	0.04	tr.
terpinolene	1.78	1.20	0.92	0.70	1.49	1.22	1.02	1.29	1.07	0.68	0.98	1.22	1.32	0.05	0.31
nonanal	0.15	0.14	0.15	0.35	0.14	0.15	0.15	0.17	0.23	0.29	0.26	0.24	0.15	0.09	0.15
linalool	9.64	7.17	5.67	12.27	6.23	8.34	7.19	8.09	5.03	10.24	7.23	27.35	9.87	7.29	19.93
citronellal	1.89	3.51	3.05	1.69	1.56	3.30	2.73	3.69	2.47	1.34	3.81	3.85	3.20	14.43	0.30
terpinen-4-ol	1.01	0.82	1.32	2.03	0.99	0.97	1.29	1.26	1.63	2.17	2.03	1.00	1.13	0.18	1.96
α -terpineol	0.65	0.40	0.17	0.62	0.21	0.34	0.19	0.31	0.10	0.25	0.16	0.60	0.43	0.11	0.24
decanal	0.10	0.10	0.13	0.11	0.05	0.10	0.14	0.09	0.10	0.25	0.15	0.10	0.12	0.03	0.38
citronellol	0.49	0.44	0.25	0.52	0.47	0.67	0.74	0.69	0.22	0.09	0.67	2.36	0.35	1.35	0.22
nerol	0.79	0.77	0.19	1.15	0.55	0.83	1.26	0.73	0.09	0.08	0.22	1.10	0.22	0.50	0.40
thymol methyl ether	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.55
neral	3.54	3.98	2.73	4.54	2.48	4.82	2.51	2.80	1.22	0.88	1.95	1.80	3.60	1.09	tr.
geraniol	0.40	0.70	0.16	0.86	0.21	0.45	0.95	0.56	0.09	0.15	0.21	0.20	0.15	0.85	tr.
geranial	4.54	5.11	3.56	6.03	3.21	6.20	3.25	3.61	1.58	1.14	2.55	2.43	4.68	1.46	tr.
thymol	0.05	0.23	0.06	0.06	0.07	0.06	0.04	0.04	0.03	0.03	0.04	0.04	0.07	tr.	0.13
undecanal	tr.	0.04	0.04	0.04	tr.	tr.	0.04	0.04	0.04	0.05	0.04	0.03	tr.	0.03	0.10
methyl geranate	0.10	0.22	0.18	0.24	0.12	0.17	0.29	0.17	0.10	0.08	0.11	0.07	0.13	tr.	tr.
citronellyl acetate	0.24	1.07	0.79	0.22	0.31	0.28	0.63	0.94	0.60	0.19	0.60	0.24	0.33	2.12	tr.
α -terpinyl acetate	0.13	0.06	-	0.05	-	-	-	0.04	-	-	-	0.13	-	-	-
neryl acetate	0.39	1.87	1.26	0.77	0.40	0.65	0.75	1.30	0.67	0.21	0.52	0.39	0.46	4.00	-
δ -elemene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11
geranyl acetate	0.48	2.06	0.94	1.49	0.30	0.91	0.62	0.79	0.64	0.51	0.66	0.13	0.69	8.13	0.04
dodecanal	0.07	0.05	0.06	0.05	0.06	0.09	0.07	0.06	0.04	0.03	0.03	tr.	0.06	0.03	0.03
β -elemene	1.32	1.42	1.34	0.47	1.30	1.79	1.33	1.09	0.87	0.62	0.66	0.10	1.24	0.72	0.07
β -caryophyllene	0.42	0.38	0.62	0.23	1.09	0.58	0.46	0.27	0.35	0.28	0.27	0.08	0.58	0.59	0.05
(Z)- β -farnesene	0.16	0.11	0.42	0.24	0.34	0.26	0.13	0.07	0.39	0.12	0.16	0.05	0.24	0.28	0.04
α -humulene	0.23	0.17	0.25	0.15	0.41	0.29	0.16	0.14	0.22	0.15	0.17	0.05	0.25	0.19	0.06

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Table 3. Chemical composition (%) of citrus leaf oils from *C. sinensis* (continued)

Grouping	STA	SHU	SGA	SJI	SHA	SWA	SRB	SVA	SLI	SXU	SXI	SIR	SRE	SGR	SXR
Compound	A	A	A	A	A	A	A	A	A	A	A	B	B	B	B
(E,E)- α -farnesene	0.06	0.03	0.07	0.08	0.07	0.04	tr.	0.04	0.05	0.02	0.03	0.12	0.06	0.12	0.10
germacrene B	0.04	0.06	0.09	0.07	0.05	0.06	0.05	0.04	0.05	0.04	0.04	0.18	0.06	0.14	0.10
δ -cadinene	0.04	0.03	0.03	0.02	0.03	0.02	0.05	tr.	0.04	tr.	0.04	0.05	0.02	0.06	0.08
elemol	0.05	0.04	0.05	0.04	0.04	0.04	0.03	0.05	0.05	0.04	0.04	0.02	0.04	0.10	0.04
(E)-nerolidol	0.04	0.04	0.07	0.06	0.04	0.05	0.03	0.05	0.06	0.03	0.06	0.07	0.05	0.22	0.07
spathulenol	-	0.07	0.05	0.03	0.10	0.05	0.04	-	0.06	0.03	0.05	0.05	tr.	0.11	0.06
caryophyllene oxide	0.04	0.06	0.06	0.04	0.07	0.03	0.02	0.04	0.06	0.04	0.04	0.06	0.02	0.13	0.08
β -eudesmol	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.12
β -sinensal	1.10	1.07	1.19	0.96	1.38	1.40	1.75	0.95	1.39	1.70	1.39	1.29	1.00	-	2.10
farnesol*	0.04	0.05	0.06	0.04	0.05	0.07	0.07	0.05	0.04	0.05	0.04	tr.	0.05	-	-
farnesal*	0.04	0.12	0.07	0.03	0.04	0.03	0.06	0.04	0.03	0.02	0.03	tr.	0.05	-	-
α -sinensal	0.29	0.13	0.15	0.30	0.39	0.32	0.15	0.17	0.15	0.22	0.13	tr.	0.23	-	-
Total	97.70	97.51	97.58	98.10	97.85	98.15	98.48	97.15	97.52	98.47	97.78	97.64	97.21	95.94	98.27

tr. = <0.02%

* correct isomer not determined

STA = *C. sinensis* cv. Taoyecheng; SHU = *C. sinensis* cv. Huangbaipitiansheng; SGA = *G. sinensis* cv. Gailiangcheng; SJI = *G. sinensis* cv. Jincheng; SHA = *G. sinensis* cv. Hamlin; SWA = *C. sinensis* cv. Washington; SRB = *C. sinensis* cv. Ruby Blood; SVA = *C. sinensis* cv. Valencia; SLI = *C. sinensis* cv. Liucheng; SXU = *C. sinensis* cv. Xuegan; SXI = *C. sinensis* cv. Xinhuiheng; SIR = *G. sinensis* x *C. reticulata*; SRE = *C. sinensis* x *C. reticulata*; SGR = *C. sinensis* x *C. grandis*; SXR = *C. sinensis* x *C. reticulata*

Table 4. Composition (%) of citrus leaf oils from *citrophorum* (citron and lemon, etc.)

Grouping	CME	MSA	MET	LEU	LLI	LVE	LBO	AME	ATA	APO	LML	JAM	LIM	LMN	LHO	BER
Compound	A	A	A	A	A	A	A	A	A	B	B	B	B	C	C	D
(E)-2-hexenal	0.02	-	-	-	0.08	-	-	0.02	-	tr.	-	-	-	-	tr.	-
(Z)-3-hexenol	-	-	-	-	0.02	-	-	-	-	tr.	0.03	-	-	-	tr.	-
α -thujene	0.03	tr.	0.02	0.07	0.07	0.05	0.05	0.14	tr.	0.26	0.03	0.24	tr.	0.14	0.14	tr.
α -pinene	1.18	0.32	0.12	1.16	0.90	0.79	0.64	0.55	0.19	1.24	0.41	1.34	0.12	2.15	1.86	0.07
camphene	tr.	0.11	tr.	0.10	0.06	0.05	0.04	tr.	tr.	0.04	tr.	0.04	tr.	0.15	0.13	tr.
6-methyl-5-hepten-2-one	1.18	0.48	0.49	0.35	0.68	0.69	1.01	0.63	0.60	0.20	0.08	0.34	0.07	tr.	0.07	tr.
sabinene	0.85	0.28	0.45	2.52	3.24	2.14	1.70	0.14	0.64	32.11	1.27	35.54	0.05	7.48	6.65	0.17
β -pinene	0.12	0.15	0.15	12.11	11.41	10.29	8.21	0.11	0.13	2.20	0.13	0.61	0.02	27.86	26.24	0.54
myrcene	1.55	1.24	0.75	0.97	1.07	1.04	1.13	0.85	0.88	2.56	1.56	12.59	0.84	1.23	1.17	2.10
α -phellandrene	tr.	tr.	tr.	tr.	0.03	0.04	0.08	-	tr.	0.05	tr.	0.07	tr.	tr.	tr.	tr.
δ -3-carene	tr.	tr.	0.03	0.17	0.90	1.00	1.46	0.04	0.03	0.03	tr.	0.03	tr.	0.02	tr.	tr.
α -terpinene	0.04	0.09	tr.	0.03	tr.	0.03	0.04	-	tr.	0.16	0.02	0.21	-	tr.	0.05	tr.
p-cymene	0.15	0.23	0.08	0.16	0.10	0.06	0.05	2.94	0.06	0.53	0.05	0.04	0.05	0.59	0.13	0.05
limonene	46.82	38.13	26.91	25.75	20.52	22.40	24.30	33.41	35.35	5.12	69.19	17.09	34.91	23.29	24.08	1.79
1,8-cineole	0.06	0.22	0.06	0.26	1.59	0.45	0.49	0.46	0.99	0.03	0.92	tr.	-	2.76	3.59	tr.
(Z)- β -ocimene	0.24	0.11	0.22	0.32	0.20	0.23	0.26	0.17	-	0.32	-	0.70	-	0.31	0.45	0.52
β -phellandrene	0.04	0.05	0.08	0.32	0.26	0.25	0.26	0.20	0.08	0.41	0.17	0.42	0.05	0.26	0.50	tr.
(E)- β -ocimene	0.32	0.16	0.38	1.67	0.90	1.09	1.28	0.66	0.71	6.48	1.65	3.59	2.11	1.01	2.35	0.92

Table 4. Composition (%) of citrus leaf oils from *citrophorum* (citron and lemon, etc.) (continued)

Grouping	CME	MSA	MET	LEU	LLI	LVE	LBO	AME	ATA	APO	LML	JAM	LIM	LMN	LHO	BER
Compound	A	A	A	A	A	A	A	A	A	B	B	B	B	C	C	D
γ -terpinene	0.16	0.09	0.16	0.10	0.11	0.10	0.11	0.02	0.03	0.56	0.11	0.39	0.06	0.11	0.53	tr.
octanol	tr.	0.03	-	0.03	tr.	tr.	tr.	0.02	tr.	0.07	tr.	0.05	-	0.03	0.05	tr.
cis-sabinene hydrate	0.08	0.02	tr.	0.07	0.07	0.05	0.05	0.02	tr.	0.59	0.03	0.58	-	0.15	0.12	0.02
cis-linalool oxide	0.03	0.05	-	0.03	-	tr.	0.05	10.06	tr.	0.12	-	-	0.08	0.08	tr.	0.05
terpinolene	0.38	0.11	tr.	0.04	0.12	0.14	0.25	tr.	0.02	0.17	0.02	0.13	tr.	0.02	0.06	0.17
nonanal	0.38	0.16	0.22	0.18	0.18	0.25	0.17	0.08	0.09	0.23	0.08	0.14	0.05	0.23	0.29	0.03
linalool	0.83	0.61	0.71	1.75	0.97	0.94	1.02	1.26	1.02	7.56	2.31	6.49	22.43	1.56	1.61	29.19
isopulegol	0.17	0.92	0.12	0.12	0.13	0.05	0.12	0.33	0.30	0.11	0.07	-	0.07	-	-	tr.
citronellal	0.97	2.13	3.22	1.65	1.51	1.92	1.52q	1.55	1.72	7.35	6.96	12.06	26.31	15.27	15.73	0.05
terpinen-4-ol	0.20	0.17	0.06	0.23	0.17	0.16	0.18	0.31	0.07	1.85	0.23	0.69	0.07	0.90	0.42	0.13
α -terpineol	0.67	0.16	0.20	0.38	0.70	0.35	0.38	0.14	0.46	0.50	0.24	0.30	0.05	1.24	1.21	9.80
decanal	0.15	0.10	0.10	0.12	0.10	0.15	0.12	0.06	0.25	0.13	-	0.33	0.07	0.08	0.58	tr.
citronellol	0.15	0.23	0.35	1.35	1.01	0.33	1.05	0.39	0.47	1.04	1.18	1.98	3.98	1.86	2.10	0.07
nerol	1.89	2.07	0.90	2.73	6.38	2.09	5.42	1.73	1.89	0.61	0.39	0.59	0.21	0.22	0.20	2.23
neral	14.56	17.15	18.96	12.22	12.36	15.56	13.67	15.86	13.77	5.30	1.31	2.22	1.78	0.57	1.43	0.30
geraniol	2.14	2.24	0.83	1.53	3.66	1.34	3.76	3.45	0.84	0.31	0.30	0.33	0.19	0.26	0.18	5.58
linalyl acetate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	28.21
geranial	18.89	23.64	25.01	15.93	15.88	20.00	17.41	22.95	18.07	7.27	1.78	3.11	2.48	0.77	1.97	0.44
thymol	-	-	tr.	-	-	tr.	-	0.09	-	0.02	0.05	1.25	0.04	tr.	tr.	tr.
undecanal	0.29	0.22	0.34	0.13	0.10	0.13	0.10	0.06	0.07	0.04	0.13	0.08	0.08	10.14	0.23	0.02
methyl geranate	0.04	0.08	tr.	0.24	0.09	0.06	0.10	0.13	0.07	0.04	tr.	tr.	0.03	0.03	tr.	tr.
citronellyl acetate	0.22	0.52	0.55	0.41	0.17	0.28	0.27	0.16	0.24	0.60	0.59	0.37	0.68	1.06	0.99	0.08
α -terpinyl acetate	-	-	-	-	-	-	-	-	0.10	-	-	-	-	-	-	0.14
neryl acetate	0.49	2.41	2.82	6.85	5.62	6.82	5.69	2.14	7.70	0.71	1.06	1.17	0.22	0.33	0.30	6.87
δ -elemene	-	-	-	-	-	-	-	-	-	-	-	0.21	-	-	-	-
geranyl acetate	1.07	3.06	10.49	2.93	2.79	4.53	3.11	4.75	4.31	1.20	0.47	0.51	0.36	1.32	0.39	5.83
dodecanal	0.24	0.03	0.05	tr.	tr.	tr.	tr.	0.06	0.05	0.07	0.06	0.05	-	-	0.09	-
β -elemene	0.26	0.04	0.04	tr.	0.03	0.03	tr.	0.23	0.17	1.48	0.79	0.06	0.03	0.09	tr.	tr.
β -caryophyllene	0.64	0.49	0.42	1.06	1.10	0.67	0.97	1.09	1.34	1.33	1.10	1.13	0.23	1.24	0.69	1.35
cis- α -bergamotene	-	0.46	0.07	0.16	0.17	0.10	0.15	0.12	0.42	0.02	0.21	0.15	0.05	0.11	0.07	0.07
(Z)- β -farnesene	0.50	-	-	0.03	0.06	0.04	0.04	-	0.06	0.37	0.17	tr.	-	0.34	tr.	-
α -humulene	0.07	0.06	0.08	0.14	0.11	0.08	0.10	0.20	0.16	0.43	0.26	0.13	0.04	0.18	0.10	0.17
γ -muurolene	-	-	-	-	-	-	-	-	0.11	-	0.07	0.13	0.05	-	0.06	-
(E,E)- α -farnesene	-	-	0.03	0.06	0.06	0.06	0.05	0.06	0.31	0.07	-	0.05	tr.	0.12	0.16	tr.
germacrene B	-	-	0.03	0.18	0.07	0.07	0.12	0.08	0.06	0.26	-	0.37	0.05	0.10	0.05	0.18
β -bisabolene	0.08	0.10	0.18	0.32	0.30	0.19	0.31	0.16	0.57	-	0.33	0.22	0.08	0.27	0.20	-
δ -cadinene	0.02	0.10	0.04	0.06	0.04	0.04	0.02	0.14	0.06	0.08	0.06	0.08	0.02	0.10	0.04	0.12
(E)-nerolidol	0.08	0.15	0.07	0.03	0.05	tr.	tr.	0.15	0.07	0.15	0.12	0.07	0.03	0.27	0.09	0.21
spathulenol	0.03	0.15	0.17	0.20	0.14	0.11	0.06	0.20	0.08	0.26	tr.	0.13	0.06	0.10	0.03	0.25
caryophyllene oxide	0.10	0.13	0.05	0.22	0.17	0.24	0.14	0.14	0.23	0.29	0.11	0.07	0.07	0.28	0.12	0.42
β -sinensal	-	-	-	-	-	-	-	-	-	2.14	-	-	-	-	-	-
Total	98.38	99.45	96.01	97.44	96.45	97.48	97.51	98.51	94.84	92.93	96.10	98.47	98.17	96.68	97.50	98.14

tr. = <0.02%.

CME = *C. medica*; MSA = *C. medica* var. *sarcodactylis*; MET = *C. medica* var. *ethrog*; LEU = *C. limon* cv. Eureka; LLI = *C. limon* cv. Lisbon; LVE = *C. limon* cv. Verna; LBO = *C. limon* cv. Botswana; AME = *C. aurantifolia* cv. Mexico; ATA = *C. aurantifolia* cv. Tahiti; APO = *C. limon* cv. Ponderosa; LML = *C. limon* var. *meyerslemon*; JAM = *C. jambhiri*; LIM = *C. limettoides*; LMN = *C. limonia*; LHO = *C. limonia* cv. Honglimeng; BER = *C. bergamia*

Table 5. Chemical composition (%) of citrus leaf oils from *cephalocitrus* (shaddock and grapefruit)

Grouping	PMA	PDU	GSH	GWU	GCH	GXI	GDI	GCU	GJI	GMA	AT	GRR	GRE	GR	GRJ	GPT
Compound	A	A	B	B	B	B	B	C	C	C	C	C	C	C	C	C
(E)-2-hexenal	-	-	-	0.06	-	-	-	-	-	-	tr.	-	0.03	-	-	-
(Z)-3-hexenol	-	-	-	tr.	-	-	-	0.04	0.03	-	0.03	-	-	-	-	-
α -thujene	0.40	0.41	0.12	0.15	0.13	0.18	0.16	0.03	0.10	0.99	1.15	1.20	1.07	tr.	1.02	0.02
α -pinene	1.70	1.25	2.15	2.02	1.95	3.06	2.46	0.59	1.27	2.88	3.14	2.87	3.36	0.65	2.58	0.25
camphene	0.05	0.05	0.17	0.16	0.18	0.22	0.21	0.04	0.08	0.07	0.07	0.06	0.11	tr.	0.08	tr.
6-methyl-5-hepten-2-one	0.03	0.07	0.22	0.35	0.11	-	-	0.76	0.25	0.04	0.04	0.16	0.03	0.51	0.03	0.11
sabinene	50.57	50.38	5.47	6.47	5.99	9.35	6.88	1.63	5.87	2.08	1.58	1.82	3.02	0.42	2.37	0.67
β -pinene	3.58	3.30	39.26	34.29	34.61	46.31	40.67	10.26	17.66	13.44	10.70	10.45	22.47	0.04	13.14	5.34
myrcene	3.53	3.18	0.66	0.90	0.95	0.65	0.61	0.90	1.20	0.77	0.92	1.10	0.79	1.08	0.69	0.40
α -phellandrene	0.09	0.09	0.02	0.05	0.03	0.93	0.02	0.02	tr.	0.04	0.03	0.06	0.05	0.86	0.03	tr.
δ -3-carene	tr.	0.02	0.02	0.67	0.31	0.04	0.05	0.03	0.03	tr.	0.03	tr.	0.53	0.05	tr.	tr.
α -terpinene	0.67	0.61	0.07	0.10	0.07	0.09	0.09	tr.	0.04	0.15	0.17	0.38	0.17	-	0.13	0.02
p-cymene	0.21	0.09	0.03	0.11	0.03	0.11	0.06	0.03	0.03	4.77	2.47	4.52	3.39	0.50	6.02	0.08
limonene	2.82	2.60	2.97	4.22	3.27	8.10	3.87	19.10	8.26	2.95	2.64	5.27	3.24	11.36	2.67	3.92
1,8-cineole	-	-	-	-	-	-	-	tr.	0.10	-	-	0.19	-	0.03	0.26	-
(Z)- β -ocimene	0.38	0.46	0.37	0.78	0.72	0.40	0.50	0.49	0.83	0.35	0.36	0.25	0.30	0.08	0.16	0.24
β -phellandrene	0.75	0.65	0.71	0.69	0.67	0.41	0.51	0.20	0.39	0.21	0.16	0.16	0.40	7.36	0.19	0.07
(E)- β -ocimene	9.23	10.47	13.60	12.82	24.57	18.31	26.23	4.86	31.19	8.92	13.40	9.82	9.29	0.61	4.68	3.94
γ -terpinene	1.68	1.20	0.17	0.92	0.19	0.23	0.36	0.03	0.16	32.66	13.75	35.38	30.66	0.08	15.06	0.19
octanol	tr.	tr.	0.03	0.03	0.03	tr.	0.02	0.02	0.04	tr.	tr.	0.04	0.03	tr.	-	-
cis-sabinene hydrate	0.45	0.36	0.15	0.09	0.05	0.03	0.04	0.05	0.09	tr.	0.04	0.02	0.03	tr.	0.07	-
cis-linalool oxide	0.09	0.04	0.05	0.05	0.11	0.02	0.04	0.02	0.05	0.04	0.04	0.03	0.03	0.07	0.03	0.33
α -p-dimethylstyrene	-	-	-	-	-	-	-	-	-	-	1.70	-	-	-	1.09	0.13
terpinolene	0.36	0.29	0.09	0.22	0.16	0.11	0.11	0.03	0.11	0.64	0.89	1.21	0.61	0.08	0.71	0.13
nonanal	0.02	0.02	-	-	-	0.28	0.15	0.15	0.19	0.02	0.02	0.03	tr.	0.07	0.04	0.02
linalool	8.18	8.51	2.31	0.91	0.71	0.24	0.65	1.14	0.56	14.87	26.67	0.45	12.59	8.54	26.59	0.50
isopulegol	0.12	0.06	-	-	-	-	-	0.05	0.20	-	0.40	-	-	0.05	0.26	0.08
citronellal	1.51	1.71	2.98	3.23	3.03	0.40	2.98	6.81	2.32	0.47	0.16	4.71	0.90	1.14	0.95	8.48
terpinen-4-ol	3.47	2.01	0.33	0.34	0.23	0.28	0.21	0.11	0.25	0.09	0.18	0.13	0.19	0.09	0.27	0.18
α -terpineol	0.24	0.20	0.12	0.07	0.09	0.06	0.05	0.15	0.14	0.10	0.33	0.15	0.14	0.28	0.37	0.26
decanal	0.20	0.23	-	0.03	0.19	0.10	0.07	0.13	0.05	0.13	0.11	0.27	0.06	0.09	0.05	1.83
citronellol	0.22	0.26	0.45	0.55	0.49	0.15	0.15	0.23	0.92	0.04	-	0.52	0.24	0.50	0.21	5.25
nerol	0.06	0.05	0.91	1.03	0.34	0.13	0.11	0.71	0.81	0.03	-	0.21	0.11	5.54	0.10	1.30
thymol methyl ether	-	-	-	-	-	-	-	-	-	0.12	7.57	-	-	-	0.40	-
neral	0.12	0.31	4.41	4.14	3.35	0.31	0.10	14.52	4.29	0.12	-	0.17	0.23	21.51	0.37	5.85
geraniol	0.09	0.09	0.91	0.90	0.71	0.13	0.02	1.62	0.73	0.06	0.10	0.04	0.12	1.65	0.09	1.14
linalyl acetate	0.09	0.09	-	-	-	-	-	-	-	-	-	-	-	-	-	-
geranial	0.24	0.46	5.08	6.18	4.48	0.42	0.02	17.87	6.20	0.19	0.03	0.28	0.29	29.24	0.52	8.43
thymol	0.04	0.07	0.02	0.03	0.04	0.02	0.20	0.05	0.05	0.09	4.81	-	0.32	-	8.52	0.07
undecanal	-	-	-	-	-	-	-	0.12	-	-	-	-	-	-	0.06	0.05
carvacrol	0.06	0.06	0.04	0.20	0.03	0.11	0.06	0.18	0.77	0.16	0.06	0.09	0.07	-	-	-
methyl geranate	-	-	tr.	0.03	0.02	tr.	tr.	tr.	-	-	0.03	-	-	0.11	-	0.08
citronellyl acetate	0.43	0.18	0.57	0.53	1.08	0.20	0.68	0.37	0.70	0.07	0.02	1.38	0.18	0.27	0.08	6.08
α -terpinyl acetate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
neryl acetate	0.28	0.11	1.42	1.03	1.62	0.30	0.15	1.90	1.00	0.05	0.08	1.29	0.20	1.84	0.16	23.14
δ -elemene	-	-	0.04	0.03	0.04	0.03	-	-	0.11	0.08	0.02	0.04	0.02	-	-	0.03
geranyl acetate	0.15	0.10	3.59	2.47	1.92	0.84	tr.	8.10	2.24	0.13	tr.	0.22	0.17	1.60	0.10	2.84
α -copaene	-	-	0.04	0.20	0.03	tr.	0.02	0.12	0.04	0.14	-	-	-	-	-	-

Table 5. Chemical composition (%) of citrus leaf oils from *cephalocitrus* (shaddock and grapefruit) (continued)

Grouping	PMA	PDU	GSH	GWU	GCH	GXI	GDI	GCU	GJI	GMA	AT	GRR	GRE	GR	GRJ	GPT
Compound	A	A	B	B	B	B	B	C	C	C	C	C	C	C	C	C
dodecanal	0.05	0.07	tr.	-	-	-	tr.	0.07	-	0.11	-	0.18	0.04	-	0.04	0.27
β -elemene	0.69	1.44	0.10	0.16	0.13	0.09	0.15	0.08	0.12	2.44	2.68	3.79	0.63	-	0.91	0.33
β -caryophyllene	0.39	1.04	1.79	1.99	0.95	1.05	2.66	0.90	2.09	1.55	0.31	2.06	0.41	0.60	0.62	3.10
cis- α -bergamotene	-	0.10	-	-	-	-	-	0.16	0.03	-	-	-	-	0.07	-	-
(Z)- β -farnesene	0.24	0.66	0.03	0.03	0.04	-	0.02	0.02	tr.	-	0.16	2.06	-	-	-	-
α -humulene	0.22	0.53	0.27	0.41	0.16	0.18	0.39	0.18	0.38	0.74	0.23	1.21	0.20	0.11	0.48	0.56
γ -muurolene	-	0.04	0.09	0.12	0.07	0.08	0.20	0.07	0.39	0.08	0.11	0.10	0.02	0.02	0.19	0.31
(E,E)- α -farnesene	0.09	0.07	0.14	0.45	0.23	0.36	0.25	0.23	0.94	0.15	0.04	0.54	0.24	-	0.32	0.16
germacrene B	0.13	0.33	1.62	4.11	1.54	1.91	2.75	0.32	2.52	0.59	0.35	0.70	0.19	0.12	0.09	2.31
valencene	-	-	0.35	0.37	0.30	-	-	0.07	0.20	0.14	0.06	0.19	0.03	-	0.08	-
β -bisabolene	-	-	-	-	-	-	-	0.43	-	-	-	-	-	0.10	-	-
δ -cadinene	0.04	0.09	0.34	0.58	0.33	0.34	0.39	0.12	0.40	0.14	0.11	0.18	0.05	0.04	0.05	0.64
elemol	0.13	0.15	-	-	-	-	-	0.16	-	0.11	0.05	0.14	-	-	0.20	-
(E)-nerolidol	0.21	0.24	0.16	0.56	0.16	0.30	0.38	0.17	0.31	0.47	0.10	0.43	0.33	0.07	0.57	0.79
spathulenol	0.25	0.24	0.56	0.42	0.74	0.67	1.11	0.42	1.15	1.14	0.55	0.24	0.34	0.13	0.38	4.47
caryophyllene oxide	0.26	0.28	0.70	0.48	0.38	0.34	0.46	0.43	0.49	0.85	0.19	0.27	0.25	0.14	0.25	1.72
β -eudesmol	-	0.31	0.28	0.45	0.25	0.36	0.28	0.15	0.34	0.89	0.09	-	0.21	-	0.15	0.74
β -sinensal	2.39	2.22	-	-	-	-	-	-	-	-	0.81	-	-	-	0.02	0.11
farnesol*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.16	0.87
farnesal*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.33	1.21
nootkatone	-	-	0.04	0.03	0.05	tr.	0.02	0.02	0.03	0.04	-	0.05	-	-	-	-
Total	97.20	97.85	96.02	97.21	97.86	98.23	97.57	97.46	98.74	97.40	99.74	97.11	98.38	97.70	94.83	99.04

tr. = <0.02%.

*correct isomer not determined

PMA = *C. paradisi* cv. Marsh; PDU = *C. paradisi* cv. Duncan; GSH = *G. grandis* cv. Shatianyou; GWU = *G. grandis* cv. Wubuhongxingyou; GCH = *G. grandis* cv. Chumenweidanyou; GXI = *C. grandis* cv. Xianluomiyou; GDI = *C. grandis* cv. Dianjiangbaiyou; GCU = *C. grandis* cv. Cuba; GJI = *C. grandis* cv. Jinxiangyou;
 GMA = *C. grandis* cv. Madoumendanyou; PAT = *C. paradisi* x *C. tangerina*; GRR = *C. grandis* cv. x *C. reticulata*; GRE = *C. grandis* x *C. reticulata*;
 LGR = *C. limon* x *C. grandis*;
 GRJ = *C. grandis* x *C. junos*; GPT = *C. grandis* x *Poncirus trifoliata*Compound Table 5

THE CHEMICAL COMPOSITION OF THE LEAF ESSENTIAL OILS

Table 6. Chemical composition (%) of citrus leaf oils from *microacrumen* (tangerine)

Grouping Compound	TCH	TDA	TFU	CHU	SUH	PON	SUC	COM	TAN	CHA	SUN	RSI	RPO	RVI	RJU	RDA	ERY	KIN	TAC
	A	A	A	B	B	B	C	C	C	D	D	D	D	D	D	D	E	E	E
(E)-2-hexenal	0.06	tr.	-	-	0.05	-	0.04	-	-	0.03	0.03	0.05	0.07	-	tr.	0.09	-	0.06	tr.
(Z)-3-hexenol	tr.*	0.02	-	0.03	tr.	-	0.02	tr.	-	0.03	tr.	0.03	tr.	-	0.03	0.05	-	tr.	tr.
α -thujene	1.16	1.31	0.82	1.13	1.53	1.09	1.18	0.79	1.22	0.43	0.45	0.46	0.55	0.39	0.39	0.45	2.25	1.32	0.08
α -pinene	2.35	2.87	1.81	2.27	3.32	2.13	2.56	1.76	2.37	1.69	1.71	2.19	1.81	1.79	1.78	1.60	4.14	4.16	1.12
camphene	0.02	tr.	tr.	0.02	0.03	0.02	0.04	0.03	tr.	0.04	0.06	0.07	0.05	0.05	0.05	0.04	0.05	0.15	0.08
sabinene	0.27	0.28	0.29	0.31	0.34	0.26	1.21	0.76	0.29	35.10	46.66	59.85	42.44	43.69	42.89	34.49	0.57	4.72	2.66
β -pinene	2.68	2.71	2.29	2.52	3.18	2.36	5.77	3.85	2.70	2.12	2.26	2.83	2.33	2.27	2.27	2.05	5.21	26.77	16.32
myrcene	0.71	0.78	0.74	0.76	1.03	0.62	0.78	0.76	0.70	2.52	2.93	3.77	2.75	3.35	2.74	2.45	1.26	0.84	1.79
α -phellandrene	0.04	0.04	0.04	0.04	0.05	0.04	0.05	0.04	0.60	0.11	0.10	0.13	0.11	0.09	0.10	0.08	0.12	0.06	1.09
δ -3-carene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.13	-	-	11.23
α -terpinene	0.25	0.23	0.22	0.29	0.36	0.34	0.37	0.26	0.44	0.66	0.82	0.70	0.74	0.75	0.71	0.67	1.28	0.44	0.13
p-cymene	2.19	2.35	2.98	4.12	3.05	2.99	9.94	9.66	16.10	0.33	0.04	0.07	0.41	0.11	0.08	0.40	5.18	2.15	0.10
limonene	2.43	2.34	2.64	8.73	2.65	2.61	4.11	5.38	3.24	1.89	1.28	2.54	1.51	2.96	2.25	1.59	4.27	2.76	9.85
(Z)- β -ocimene	0.37	0.40	0.28	0.25	0.52	0.27	0.32	0.35	0.16	0.25	0.23	0.18	0.26	0.37	0.48	0.37	0.18	0.16	0.50
β -phellandrene	tr.	tr.	-	0.03	-	tr.	0.08	0.07	tr.	0.57	0.45	0.61	0.43	0.57	0.44	0.35	0.03	0.04	0.91
(E)- β -ocimene	6.47	6.42	8.22	4.87	10.72	6.53	10.90	9.18	3.42	4.24	5.99	5.08	5.82	6.37	10.48	7.12	4.69	2.76	10.37
γ -terpinene	8.64	7.89	8.55	13.68	16.64	16.47	15.01	13.01	16.09	5.59	1.38	1.30	2.11	1.89	1.39	2.02	54.43	13.47	0.14
cis-sabinene hydrate	0.02	0.04	0.02	0.06	0.05	0.07	0.06	0.05	0.09	1.00	1.23	0.88	0.83	0.90	0.57	0.62	0.05	0.12	0.06
cis-linalool oxide	0.02	0.04	0.06	0.03	0.07	0.08	0.02	0.03	0.03	0.03	0.05	0.08	0.07	0.08	0.10	0.10	0.02	0.03	0.04
α -p-dimethylstyrene	1.32	1.12	1.26	1.03	0.90	0.55	4.14	3.59	3.69	0.32	0.37	0.36	0.27	0.26	0.24	0.43	0.07	0.57	-
terpinolene	1.24	1.27	0.59	1.13	1.53	1.04	1.19	1.09	1.27	0.47	0.35	0.33	0.46	0.36	0.33	0.44	2.45	1.33	1.63
nonanal	0.04	0.03	0.04	0.06	0.03	0.04	0.03	0.04	0.08	0.06	0.03	0.08	0.04	0.06	0.06	0.08	0.02	0.06	0.05
linalool	50.84	40.44	49.04	40.05	32.52	46.77	38.17	43.74	43.64	32.22	26.72	10.61	28.03	22.03	23.74	32.63	10.42	22.97	33.74
citronellal	0.41	0.39	0.43	0.03	0.30	0.03	0.23	0.26	0.30	0.12	0.09	0.07	0.06	0.08	0.07	0.04	tr.	0.24	0.03
terpinen-4-ol	0.14	0.12	0.11	0.24	0.18	0.22	0.23	0.13	0.28	2.75	3.00	2.40	2.22	2.85	2.24	2.67	0.14	0.42	0.22
α -terpineol	0.23	0.24	0.24	0.41	0.32	0.41	0.39	0.35	0.48	0.96	0.87	0.39	0.48	0.38	0.18	0.37	0.18	0.62	0.34
decanal	0.03	0.03	-	0.07	0.05	0.08	0.05	0.07	0.09	0.14	0.08	0.08	0.16	0.10	0.05	0.15	0.03	0.06	0.06
citronellol	0.06	0.10	-	0.08	-	0.08	-	0.04	0.02	0.10	0.06	0.05	-	-	-	-	tr.	0.08	0.07
nerol	-	-	-	-	-	-	-	0.03	0.09	-	-	-	-	-	-	-	-	-	0.18
thymol methyl ether	7.95	7.43	9.10	0.08	0.48	0.05	-	0.62	-	-	0.04	-	1.14	-	-	-	0.09	0.04	-
neral	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
geraniol	-	-	-	-	-	-	-	0.04	0.06	-	-	-	-	-	-	-	-	-	0.12
linalyl acetate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.61
thymol	6.67	7.10	7.48	12.56	15.14	10.24	0.05	0.41	0.05	0.02	0.03	0.03	0.13	0.02	0.02	1.04	0.14	9.83	0.83
undecanal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
carvacrol	0.05	0.04	0.04	0.04	0.05	0.06	0.03	0.03	0.02	0.07	0.04	0.04	0.05	0.11	0.05	0.04	0.03	0.04	-
methyl geranate	-	-	-	-	-	-	tr.	-	-	0.03	-	-	-	0.02	-	-	-	-	-
citronellyl acetate	-	-	-	-	-	-	-	-	-	-	-	-	-	0.11	-	-	-	-	0.32
α -terpinyl acetate	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
neryl acetate	-	-	-	-	-	-	-	0.03	-	0.05	-	-	-	0.05	-	-	-	-	0.33
δ -elemene	0.07	0.18	0.08	-	-	-	-	0.04	-	-	0.17	0.18	0.14	0.07	0.02	0.18	0.05	-	0.06
geranyl acetate	-	-	-	0.03	-	-	-	0.02	-	tr.	-	-	-	-	-	-	-	-	0.22
β -elemene	0.06	0.13	0.15	0.55	0.03	0.02	0.46	0.80	0.73	0.09	0.11	0.81	0.08	0.04	0.02	1.21	0.19	0.05	0.06
β -caryophyllene	0.07	0.19	0.22	0.22	1.01	0.11	0.24	0.36	0.35	1.05	0.20	0.42	0.11	1.16	0.51	0.50	0.08	0.22	0.49
(Z)- β -farnesene	-	-	-	0.30	-	0.09	-	-	-	-	-	-	-	0.11	-	-	-	0.04	-
α -humulene	0.06	0.10	0.11	0.24	0.17	0.03	0.16	0.18	0.15	0.16	0.06	0.18	0.05	0.17	0.08	0.24	0.05	0.06	0.14
γ -muurolene	0.06	0.22	0.07	-	-	-	-	0.03	-	0.10	0.12	0.12	0.09	-	-	0.12	0.04	-	0.18
(E,E)- α -farnesene	0.05	0.07	0.04	0.07	0.11	-	0.05	0.04	-	0.09	-	0.07	0.07	0.21	0.27	0.07	0.02	0.25	-
germacrene B+	0.28	0.72	0.34	0.08	0.16	0.15	0.04	0.12	0.17	0.90	0.08	0.11	0.34	0.47	1.53	0.60	0.02	0.18	0.33
valencene+	0.05	0.09	-	0.02	0.02	-	0.08	0.16	-	0.77	-	-	-	0.09	0.04	0.04	-	0.10	-
δ -cadinene	0.06	0.19	0.14	0.04	0.03	0.04	0.02	0.05	0.07	0.08	0.05	0.04	0.07	0.07	0.13	0.09	tr.	0.05	0.12
elemol	0.04	0.05	0.04	0.03	0.04	0.03	0.04	0.05	0.09	0.03	0.03	0.06	0.02	0.05	0.03	0.08	0.05	-	0.17
(E)-nerolidol	0.09	0.10	0.08	0.05	0.11	0.05	0.12	0.20	0.10	0.13	0.07	0.06	0.06	0.10	0.10	0.07	0.04	0.13	0.27
spathulenol	0.18	0.04	0.04	0.03	0.06	0.09	tr.	0.09	tr.	0.03	tr.	tr.	tr.	tr.	tr.	tr.	0.02	tr.	0.12

Table 6. Chemical composition (%) of citrus leaf oils from *microacrumen* (tangerine) (continued)

Grouping Compound	TCH	TDA	TFU	CHU	SUH	PONSUC	COM	TAN	CHA	SUN	RSI	RPO	RVI	RJU	RDA	ERY	KIN	TAC	
	A	A	A	B	B	B	C	C	C	D	D	D	D	D	D	D	E	E	E
caryophyllene oxide	0.19	0.05	0.05	0.07	0.11	0.09	tr.	0.03	0.06	0.05	tr.	tr.	0.06	tr.	tr.	tr.	0.05	tr.	0.03
β-eudesmol	0.04	0.12	0.13	0.04	0.05	0.04	0.04	0.07	-	0.20	0.10	0.10	0.10	0.15	0.17	0.14	0.04	0.13	0.20
β-sinensal	-	-	-	0.94	tr.	2.54	-	-	-	0.05	-	tr.	0.84	tr.	tr.	tr.	0.96	-	-
α-sinensal	0.48	0.52	0.50	0.12	1.57	0.02	0.20	0.30	-	tr.	-	0.38	0.26	1.67	1.56	0.65	tr.	-	-
Total	98.44	88.80	99.28	97.75	98.56	98.75	98.42	98.99	99.24	97.67	98.34	97.79	97.73	96.31	98.19	97.55	98.95	97.44	97.39

tr. - <0.02%

TCH = *C. tangerina* cv. Chuanju; TDA = *C. tangerina* cv. Dancy; TFU = *C. tangerina* cv. Fujui; CHU = *C. chuana*; SUH = *C. suhuiensis*; PON = *C. ponki*; SUC = *C. succosa*;COM = *C. compressa*; TAN = *C. tandiferax*; CHA = *C. chachiensis*; SUN = *C. sunki*; RSI = *G. reticulata* cv. Sihuishiyueju; RPO = *C. reticulata* var. *poonensis*; RVI = *C. reticulata* cv. Vietnamese; RJU = *C. reticulata* cv. Jushaxianggan; RDA = *C. reticulata* cv. Daxianggan; ERY = *C. erythrosa*; KIN = *C. kinokuni*; TAC = *C. tachibana*Table 7. Chemical composition (%) of citrus leaf oils from *macroacrumen* (mandarin)

Compound	CLE	SUA	VES	NWA	NBE	UWE	TAK	IY0	SUL	HAS	MAD
α-thujene	0.54	0.72	1.21	0.58	0.74	1.96	0.02	0.78	0.90	0.99	0.35
α-pinene	1.53	1.56	2.70	2.21	1.70	4.02	0.09	1.92	2.32	2.37	1.28
camphene	0.05	tr.	0.05	0.08	0.04	0.07	tr.	0.05	0.05	0.04	0.03
6-methyl-5-hepten-2-one	0.20	-	-	-	0.19	-	0.18	-	-	-	-
sabinene	33.94	0.26	1.90	57.28	0.89	1.47	0.02	1.82	1.53	1.19	26.71
β-pinene	1.90	2.26	6.17	3.75	5.07	9.20	tr.	9.50	9.53	6.83	1.62
myrcene	2.50	0.86	0.88	3.70	14.37	1.27	0.94	0.62	0.90	0.87	1.72
α-phellandrene	0.14	0.08	0.05	0.12	0.03	0.10	0.24	0.03	0.05	0.03	0.06
δ-3-carene	6.26	-	tr.	0.02	tr.	-	5.64	-	-	-	-
α-terpinene	0.49	0.34	0.34	0.88	0.15	0.70	0.05	0.18	0.34	0.14	0.30
p-cymene	0.28	16.54	3.96	0.07	6.70	20.47	0.11	9.50	3.72	8.88	0.33
limonene	3.63	2.99	3.32	4.91	4.10	4.27	2.78	2.15	3.21	3.56	1.25
1,8-cineole	-	-	-	1.00	0.07	0.06	0.04	0.11	0.18	-	-
(Z)-β-ocimene	0.55	0.38	0.31	0.22	0.08	0.08	0.42	0.24	0.33	0.27	0.20
β-phellandrene	0.52	0.29	0.09	0.63	0.13	0.15	0.24	0.16	0.18	0.10	0.27
(E)-β-ocimene	3.46	9.45	10.11	6.61	2.62	6.39	9.03	7.17	9.95	11.67	3.51
γ-terpinene	1.64	21.71	13.59	1.67	24.48	36.28	0.07	15.77	42.52	43.63	2.49
cis-sabinene hydrate	1.02	0.05	0.11	0.64	0.03	0.08	0.11	0.07	tr.	tr.	0.72
cis-linalool oxide	0.21	0.02	0.02	0.03	0.03	0.04	0.02	0.02	tr.	tr.	0.02
α-p-dimethylstyrene	-	3.77	1.99	-	-	2.76	-	1.39	-	-	0.15
terpinolene	1.27	1.71	1.19	0.40	0.64	2.02	0.79	0.77	1.27	0.92	0.31
nonanal	0.15	0.04	0.09	0.14	0.15	0.03	0.19	0.06	0.04	-	0.17
linalool	22.55	30.13	33.75	5.52	2.81	4.06	63.46	41.09	10.86	0.90	50.02
citronellal	2.59	0.04	0.38	0.08	5.93	0.28	1.29	0.08	0.10	1.56	0.06
terpinen-4-ol	2.95	0.19	0.38	2.76	0.18	0.29	0.12	0.20	0.16	0.20	0.90
α-terpineol	0.92	0.35	0.69	0.13	0.25	0.16	0.34	0.43	0.09	0.10	0.57
decanal	0.06	0.11	0.02	0.06	0.11	0.10	0.05	0.04	0.05	0.25	0.07
citronellol	1.85	0.03	0.12	0.05	0.51	tr.	0.25	0.04	0.05	0.26	0.05
nerol	0.60	0.04	0.02	tr.	0.56	0.02	0.39	0.04	0.21q	0.13	0.03
thymol methyl ether	-	-	0.08	0.06	-	-	-	0.05	-	0.15	tr.
neral	0.30	-	-	-	2.77	0.02	0.84	0.03	0.03	tr.	tr.
geraniol	0.68	0.04	-	0.02	0.93	0.03	0.27	0.05	0.08	0.09	-
geranial	0.42	-	-	-	3.70	0.02	1.10	0.07	0.04	tr.	-
thymol	0.03	0.04	11.55	0.03	0.03	0.04	0.18	0.03	0.04	0.05	2.13
carvacrol	0.02	0.02	0.06	0.06	0.04	0.09	0.05	0.02	0.07	tr.	0.03
methyl geranate	0.16	-	0.02	-	0.04	-	0.13	-	-	-	-
citronellyl acetate	0.05	-	tr.	tr.	1.08	tr.	0.21	0.03	0.15	1.89	tr.
α-terpinyl acetate	-	-	-	-	-	-	-	-	-	-	-
neryl acetate	0.08	-	tr.	tr.	3.38	0.03	1.63	0.07	2.57	1.79	0.03

Continued on next page

Table 7. Chemical composition (%) of citrus leaf oils from *macroacrumen* (mandarin) (continued)

Compound	CLE	SUA	VES	NWA	NBE	UWE	TAK	IYO	SUL	HAS	MAD
δ -elemene	-	-	-	-	-	-	-	-	0.16	-	-
geranyl acetate	0.57	-	tr.	tr.	10.53	-	2.78	0.13	0.05	0.25	tr.
dodecanal	-	-	-	0.06	-	-	-	-	-	-	-
β -elemene	-	1.45	0.45	1.52	0.87	0.85	0.04	0.14	0.15	2.32	1.15
β -caryophyllene	0.15	0.56	0.14	0.78	0.47	0.42	0.26	0.29	1.43	1.86	0.44
(Z)- β -farnesene	0.03	-	-	0.47	0.63	-	0.13	0.19	1.69	-	-
α -humulene	tr.	0.30	0.07	0.37	0.21	0.18	0.07	0.11	0.22	0.74	0.21
γ -muurolene	-	0.04	-	-	-	-	-	0.05	0.28	0.05	-
(E,E)- α -farnesene	0.03	0.17	0.05	0.34	0.10	0.11	0.05	0.12	tr.	0.08	-
germacrene B	0.04	0.12	0.04	0.05	0.08	0.09	0.44	0.31	0.76	0.31	0.11
valencene	-	0.19	-	-	-	-	0.05	0.03	0.58	0.15	-
δ -cadinene	0.07	0.06	0.02	0.03	0.03	0.05	0.12	0.09	0.14	0.25	0.04
elemol	0.06	0.12	0.05	0.09	0.13	-	0.07	0.03	0.20	0.04	0.04
(E)-nerolidol	0.14	0.16	0.15	0.15	0.13	0.15	0.06	0.13	0.55	0.23	0.06
spathulenol	-	-	0.16	tr.	0.10	0.09	0.26	0.28	0.34	0.81	tr.
caryophyllene oxide	0.04	0.02	0.02	0.16	0.04	0.04	0.03	0.03	0.27	0.32	0.04
β -eudesmol	0.03	0.07	0.10	0.18	0.17	0.11	0.05	0.13	0.18	0.20	0.03
β -sinensal	1.49	0.04	0.02	-	-	-	2.67	0.99	0.07	2.02	1.49
α -sinensal	0.58	0.55	0.43	-	-	-	0.32	0.47	0.02	-	0.58
Total	96.77	97.87	96.85	97.91	98.02	98.65	98.69	98.10	98.61	98.49	99.57

tr. = <0.02%

CLE = *C. clementina*; SUA = *C. suavissima*; VES = *C. vessucosa*; NWA = *C. nobilis* cv. Wanggan; NBE = *C. nobilis* cv. Bendiguanju;
 UWE = *C. unshiu* cv. Wenzhang; TAK = *C. tankan*; IYO = *C. iyo*; SUL = *C. sulcata*; HAS = *C. hassaku*; MAD = *C. madurensis*

