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The chemical composition and antioxidant activities of basil from Thailand using retention indices and comprehensive two-dimensional gas chromatography

PATCHAREE PRIPDEEVECH[1]*, WATCHARAPONG CHUMPOLSRI[2], PANAWAN SUTTIARPORN[2] and SUGUNYA WONGPORNCHAI[2]

[1]*School of Science, Mae Fah Luang University, Chiang Rai, 57100 and* [2]*Department Center of Excellence for Innovation in Chemistry, Department of Chemistry, Faculty of Science, Chiang Mai University, Chiang Mai, 50200, Thailand*

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Abstract: The chemical compositions of essential oils obtained from *Ocimum basilicum* var. *thyrsiflora* (1.39 % dry weight) and *Ocimum basilicum* (0.61 %) were analyzed by GC–MS. Seventy-three constituents representing 99.64 % of the chromatographic peak area were obtained in the *O. basilicum* var. *thyrsiflora* oil, whereas 80 constituents representing 91.11 % observed in the essential oil of *O. basilicum* were obtained. Methyl chavicol (81.82 %), *β*-(*E*)-ocimene (2.93 %) and *α*-(*E*)-bergamotene (2.45 %) were found to be the dominant constituents in *O. basilicum* var. *thyrsiflora* oil while *O. basilicum* contained predominantly linalool (43.78 %), eugenol (13.66 %) and 1,8-cineole (10.18 %). The clear separation of the volatiles in all samples, demonstrated by the application of GC×GC, resulted in significantly different fingerprints for the two types of basil. The *O. basilicum* oil showed strong antioxidant activity while the oil of *O. basilicum* var. *thyrsiflora* exhibited very low activity, which was attributed to the significant differences in linalool and eugenol contents in these essential oils.

Keywords: *O. basilicum*; *O. basilicum* var. *thyrsiflora*; DPPH radical scavenging activity; simultaneous distillation and extraction (SDE); comprehensive two-dimensional gas chromatography; GC×GC.

INTRODUCTION

Basil (*Ocimum basilicum*), belonging to the Lamiaceae family, is one of the most popular plants grown extensively in many continents around the world, especially in Asia, Europe and North America. Basil is believed to have originated in Iran and/or India. At least 150 species of the genus *Ocimum* are widely

* Corresponding author. E-mail: patcharee_pri@mfu.ac.th
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cultivated in other countries of Asia.[1] Although several basil species are found in many regions, the species *O. basilicum* is the most cultivated variety in the world.[2–4] Basil has been planted as a popular culinary and medicinal herb from ancient time until now and the leaves and flowers have been used for the treatment of headaches, coughs, diarrhea, worms and kidney malfunctions, as well as for its carminative, galactagogue, stomachic and antispasmodic properties.[1,5–7] Basil contains a wide range of phenolic compounds displaying various antioxidant activities, depending on the basil species and cultivars.[8–11] The extracts of basil obtained by different methods are considered to be antimicrobial,[12–14] insecticidal[15] and useful in a number of medical treatments.[16–18] The essential oils of basil are used in the flavoring of food and in perfumery because of their aromatic properties.[19] There are significant differences in the chemical composition and amounts and kinds of aromatic components in the essential oils of basil depending on the species and environmental conditions of the cultivation location. For instance, basil having dark green leaves and white flowers, the popular cultivars for the fresh market and garden, possesses a rich spicy pungent aroma due to the presence of linalool, methyl chavicol and 1,8-cineole.[19] Lesser cultivars vary in growth habit, size, and color, and can display a wide range of aromas including, lemon, rose, camphor, licorice, wood and fruit.[19] The dark opal cultivar with purple color in all parts contains linalool and 1,8-cineole as the major components while camphor is dominant in the basil camphor cultivars.[19] The basil cultivars of India, Pakistan and Guatemala exhibit methyl cinnamate as the dominant component.[20,21] Basil essential oils include mainly the group of terpenoid components, which includes monoterpenes and sesquiterpenes as well as their oxygenated derivatives.[22,23]

The similarity of the structures of the constituents has obstructed component identification. To date, gas chromatography–mass spectrometry (GC–MS) has played the most important role in the identification of the chemical composition of basil essential oils. Nevertheless, incomplete identification was achieved by the use of GC–MS due to the complex nature of the constituents of the essential oil. Comprehensive two-dimensional gas chromatography (GC×GC) is a powerful technique that has been successfully used for the separation of the volatile constituents in highly complex samples, especially essential oils.[24–26] This technique is a combination of two columns with different separation mechanisms coupled *via* a cryogenic modulator interface. Many co-eluting components on the first column are separated in the second column. This rapid technique displays significant differences between samples, making it a valuable technique for application in qualitative analysis. The application of comprehensive two-dimensional gas chromatography coupled to time-of-flight mass spectrometry (GC×GC–––TOFMS) has been employed to analyze the aromatic compounds of basil samples.[27] Linalool, methyl chavicol, eugenol, and 1,8-cineole were the dominant com-

pounds identified in these samples. The relative abundances of the different constituents allowed differentiation between the examined cultivars.

In the present study, *O. basilicum* var. *thyrsiflora* and *O. basilicum* plants were grown in northern Thailand. The chemical compositions of the essential oils of the leaves of both cultivars were identified by using GC–MS and confirmed by the linear retention indices. The use of GC×GC with a longitudinally modulated cryogenic system (LMCS) was also employed to clearly differentiate between the fingerprints of these oil samples. Additionally, the analyses of the volatile constituents of all oils were completed by an evaluation and determination of the antioxidant activities of the essential oil samples.

EXPERIMENTAL

Plant materials and chemicals

Aerial parts of two varieties of basil, *O. basilicum* var. *thyrsiflora* and *O. basilicum*, were collected at flowering stage in the Chiang Rai province located in the northern part of Thailand (altitude 390 m) in June 2008. Voucher herbarium specimens (QBG No. 41462 and QBG No. 41463) of *O. basilicum* var. *thyrsiflora* and *O. basilicum* plant, respectively, were identified and deposited at the Queen Sirikit Botanic Garden, Mae Rim, Chiang Mai, Thailand. The morphology of *O. basilicum* var. *thyrsiflora* and *O. basilicum* plants differ significantly. *O. basilicum* var. *thyrsiflora* plant has narrow green leaves, purple–red stems and violet pink flowers, whereas *O. basilicum* plant has light-green stems, elliptic–ovate leaves and white flowers. The leaves were separated by hand and then dried in the shade for 10 days before being subjected to simultaneous distillation–extraction (SDE). All basil essential oil samples obtained were diluted 1:10 v/v with *n*-hexane prior to injection into the GC–MS and GC×GC instruments. All chemicals were of analytical grade and consisted of dichloromethane, anhydrous sodium sulfate, mixtures of C_8 to C_{22} *n*-alkanes and 2,2-diphenyl-1-picrylhydrazyl (DPPH) which were purchased from Merck (Darmstadt, Germany), and gallic acid, purchased from Sigma–Aldrich GmbH. (Steinheim, Germany).

Gas chromatography–Mass spectrometry (GC–MS)

The volatile constituents of basil leaf oils were analyzed using a Hewlett Packard model HP6890 gas chromatograph (Agilent Technologies, Palo Alto, CA, USA) equipped with an HP-5MS (5 % phenyl-polymethylsiloxane) capillary column (30 m×0.25 mm i.d., film thickness 0.25 μm; Agilent Technologies, USA) interfaced to an HP model 5973 mass-selective detector. The oven temperature was initially held at 100 °C and then increased at 2 °C min^{-1} to 220 °C. The injector and detector temperatures were 250 and 280 °C, respectively. Purified helium was used as the carrier gas at a flow rate of 1 mL min^{-1}. The EI mass spectra were collected at an ionization voltage of 70 eV over the *m*/*z* range 29–300. The electron multiplier voltage was 1150 V. The ion source and quadrupole temperatures were set at 230 and 150 °C, respectively. Identification of volatile components was performed by comparison of their Kováts retention indices, relative to C_8–C_{22} *n*-alkanes, and comparison of the mass spectra of individual components with the reference mass spectra in the Wiley 275 and NIST 98 databases and with the corresponding data for components in basil.[10,19,28,29]

Comprehensive two-dimensional gas chromatography (GC×GC)

A gas chromatograph, model HP 6890, equipped with an FID detector and an HP 6890 series auto sampler was used for the GC×GC–FID experiments and was operated at 100 Hz

data acquisition. The GC was retrofitted with a longitudinally modulated cryogenic system, LMCS (Chromatography Concepts, Doncaster, Australia). CO_2 was employed as the cryogen, which was thermostatically controlled at about –20 °C for the duration of each run. The injection temperature was 250 °C with an injection volume of 1.0 µL in the split mode with a split ratio of 100:1. The injection and detector temperature were operated at 250 °C. Hydrogen gas was used as the carrier gas at a flow rate of 1.5 mL min^{-1}. The GC was operated in the constant flow mode. The column set for GC×GC analysis consisted of two capillary columns which were serially coupled by a zero-dead-volume fitting. The column sets and operation conditions used in this experiment are listed in Table I. The columns are available from SGE International (Ringwood, Australia). The GC×GC column set BPX5/BP20 (Column set 1) was 5 % phenyl polysilphenylene-siloxane connected to a polyethylene glycol phase, which separates most components according to boiling point rather than polarity, while the separation polar/non-polar was obtained using the column set Solgel wax/BP1 (Column set 2) which is the combination of an inverse phase of poly(ethylene glycol) and 100 % dimethylpolysiloxane. Both column sets were selected to investigate the basil volatiles in all samples due to the different properties of these column sets.

TABLE I. GC×GC column sets and temperature programs

Condition	Set 1		Set 2	
	^{1}D	^{2}D	^{1}D	^{2}D
Stationary phase	BPX5	BP20	Solgel Wax	BP1
Length, m	30	2.0	30	2.0
Diameter, mm	0.25	0.10	0.25	0.1
Film thickness, µm	0.25	0.10	0.25	0.10
Modulation period, s	6		6	
Temperature program	from 120 to 180 °C at 1 °C min^{-1}		from 80 to 250 °C at 2 °C min^{-1}	

Antioxidant activity

DPPH radical scavenging assay. The radical scavenging abilities of *O. basilicum* var. *thyrsiflora* and *O. basilicum* essential oils based on reaction with the 2,2-diphenyl-2-picrylhydrazyl radical (DPPH˙) were evaluated by a spectrophotometric method based on the reduction of a methanol solution of DPPH according to a modified method of Blois.[30] One milliliter of various concentrations of the each oil in methanol was added to 1 mL of a 0.003 % methanol solution of DPPH and the reaction mixture was shaken vigorously. The tubes were allowed to stand at room temperature (27 °C) for 30 min. Each reaction mixture was then placed in the cuvette holder of a Perkin Elmer-Lambda 25 UV/Vis spectrophotometer and monitored at 517 nm against a methanol blank. The scavenging ability was calculated as follows: scavenging ability = 100×(absorbance of control – absorbance of sample/absorbance of control). The antioxidant activity of all essential oils is expressed as IC_{50}, which is defined as the concentration (in µg mL^{-1}) of oil required to inhibit the formation of DPPH radicals by 50 %. The experiment was performed in triplicate.

Determination of the total phenolic contents. Total phenolic content of the essential oils obtained from *O. basilicum* var. *thyrsiflora* and *O. basilicum* leaves was determined using Folin–Ciocalteu reagent according to a modified method of Singleton and Rossi[31] using gallic acid as the standard. The oil solution (0.2 mL) was mixed with 1.0 mL of Folin–Ciocalteu reagent, 1.0 mL of a 7 % aqueous solution of Na_2CO_3 and 5.0 mL of distilled water. Then, the mixture was vigorously vortexed. The reaction mixtures were allowed to stand for 30 min

before the absorbance at 765 nm was measured. The concentration of both essential oils was set to 5 mg mL^{-1}. The same procedure was also applied to standard solutions of gallic acid. The calibration equation for gallic acid was:

$$y = 0.00515x - 0.00400 \ (R^2 = 0.999)$$

where y is the absorbance and x is the concentration of gallic acid in mg mL^{-1}.

RESULTS AND DISCUSSION

The essential oil of the leaves of *O. basilicum* var. *thyrsiflora* and *O. basilicum* were extracted using a modified Likens–Nickerson apparatus and appeared as viscous yellow liquids with a percentage yield of 1.39 and 0.61 (w/w), respectively. These essential oils were subjected to detailed GC–MS analysis in order to determine the volatile constituents. Overall, 81 volatile constituents were identified among the two basil leaf oil samples. The GC–MS chromatograms of all samples are shown in Fig. 1. The structures of the volatile components identified by GC–MS, their relative area percentages and their retention indices are summarized in Table II. Although the oils of the two *O. basilicum* species contained high percentages of the same group of monoterpenes and sesquiterpenes, the different varieties presented significant variability in their chemical compositions. A total of 73 constituents representing 99.64 % of the *O. basilicum* var. *thyrsiflora* leaf oil were established. The dominant components were methyl chavicol (81.82 %), *β*-(*E*)-ocimene (2.93 %), *α*-(*E*)-bergamotene (2.45 %), *α*-epi-cadinol (2.08 %), 1,8-cineole (1.62 %), methyl eugenol (1.10 %) and camphor (1.09 %). As indicated, pentyl butanoate was distinguished only in *O. basilicum* var. *thyrsiflora* essential oil. The present studies are similar to the published research of Simon *et al.*,[19] who reported methyl chavicol (60 %) and linalool (12 %) as the major constituents in the essential oil of *O. basilicum* var. *thyrsiflora*; Thai (Richters).

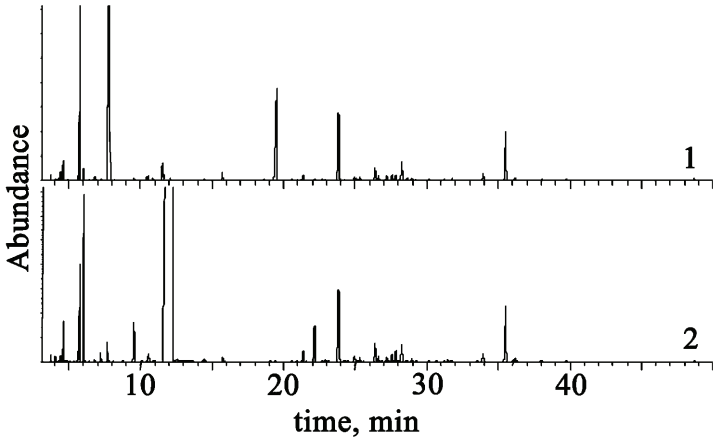

Fig. 1. GC-MS chromatogram of volatile component profiles of (1.1 above) *O. basilicum* essential oil, (1.2) *O. basilicum* var. *thyrsiflora* essential oil.

TABLE II. Structural assignment and relative peak area percent of the volatile components of the essential oil obtained from of *O. basilicum* (A) and *O. basilicum* var. *thyrsiflora* (B) leaves

Component	*LTPRI*[a]	Relative peak area, %		Component	*LTPRI*	Relative peak area, %	
		A	B			A	B
(*E*)-2-Hexenol	849	0.06	0.03	Methyl chavicol	1196	0.21	81.82
α-Thujene	924	0.01	t	Geraniol	1253	0.03	0.01
α-Pinene	932	0.19	0.07	Chavicol	1259	0.07	0.09
Camphene	949	0.03	0.06	*iso*-Bornyl acetate	1283	0.65	0.11
Sabinene	971	0.33	0.08	Carquejol acetate	1295	0.05	t
Amyl vinyl carbinol	974	0.04	0.02	*α*-Cubebene	1344	0.03	0.02
β-Pinene	978	0.57	0.16	Eugenol	1355	13.66	0.02
β-Myrcene	988	0.76	0.49	*exo*-2-Hydroxycineole acetate	1358	0.04	–
Dehydro-1,8-cineole	991	0.02	0.01	*α*-Ylangene	1373	0.08	0.02
para-Mentha-1(7),8--diene	1007	t	0.01	*β*-Bourbonene	1380	0.10	0.03
α-Terpinene	1017	0.02	0.01	*iso*-Longifolene	1385	0.06	0.03
ortho-Cymene	1024	0.01	0.01	*β*-Elemene	1387	0.47	0.31
Limonene	1028	0.23	0.15	Cyperene	1391	0.05	0.02
1,8-Cineole	1033	10.18	1.62	Methyl eugenol	1400	0.09	1.10
β- (*E*)-Ocimene	1044	0.57	2.93	*α*-Cedrene	1410	0.09	0.04
γ-Terpinene	1056	0.06	t[b]	(*E*)-Caryophyllene	1416	0.08	0.06
(*Z*)-Sabinene hydrate	1071	0.23	0.03	*β*-Cedrene	1420	0.04	0.02
Caprylyl acetate	1078	0.08	t	*β*-Copaene	1426	t	–
Terpinolene	1084	0.06	0.15	*α*-(*E*)-Bergamotene	1431	0.10	2.45
Linalool oxide	1087	0.07	–	*β*-(*Z*)-Farnesene	1438	0.05	0.05
Pentyl butanoate	1095	–	0.01	(*Z*)-Muurola-3,5--diene	1442	0.05	0.03
Linalool	1099	43.78	0.43	*α*-Humulene	1451	0.36	0.18
(*E*)-Sabinene hydrate	1099	0.17	–	*β*-(*E*)-Farnesene	1454	0.20	0.08
(*Z*)-Myroxide	1138	0.01	–	(*Z*)-Muurola--4(14),5-diene	1458	0.35	0.13
Camphor	1146	0.20	1.09	*β*-Acoradiene	1462	0.04	0.02
iso-Menthone	1162	0.03	0.03	*γ*-Gurjunene	1471	0.06	0.02
δ-Terpineol	1170	0.28	–	*γ*-Muurolene	1477	1.35	0.60
Borneol	1172	0.36	0.32	*γ*-Himachalene	1481	0.47	0.18
Terpinen-4-ol	1179	0.18	0.06	*β*-Selinene	1485	0.04	0.04
γ-Terpineol	1195	1.75	–	Bicyclogermacrene	1491	0.04	0.18
β-(*E*)-Guaiene	1498	0.59	0.27	1,10-Di-epi-cubenol	1611	0.76	0.29
γ-Patchoulene	1503	0.51	0.35	*β*-Acorenol	1629	0.05	0.01
β-Bisabolene	1505	0.09	0.04	*α*-Epi-cadinol	1640	5.76	2.08
γ-Cadinene	1509	1.99	0.57	*β*-Eudesmol	1650	0.11	0.09
(*E*)-Calamenene	1516	0.35	0.06	*α*-Cadinol	1652	0.32	0.14
(*Z*)-Nerolidol	1521	0.30	0.11	*α*-Epi-bisabolol	1683	0.06	0.03

TABLE II. Continued

Component	*LTPRI*[a]	Relative peak area, %		Component	*LTPRI*	Relative peak area, %	
		A	B			A	B
α-Cadinene	1533	0.03	0.01	α-Bisabolol	1685	0.10	0.04
Longicamphenylone	1560	0.08	0.02	Zierone	1698	0.03	t
Spathulenol	1573	0.25	0.03	β-(*Z*)-Santalol	1713	0.12	0.03
(*E*)-Sesquisabinene hydrate	1579	0.01	–	(*E*)-3-Tetradecen-5--yne	1889	0.24	0.05
β-(*Z*)-Elemenone	1580	0.06	0.03				

[a]Linear temperature program retention index; [b]trace amount, < 0.005 %

Individually, *O. basilicum* leaf oil yielded 80 identified constituents representing 91.11 % with dominant components consisting of linalool (43.78 %) followed by eugenol (13.66 %), 1,8-cineole (10.18 %), α-epi-cadinol (5.76 %), γ-cadinene (1.99 %), γ-terpineol (1.75 %) and γ-muurolene (1.35 %), respectively. As can be observed, eight components (linalool oxide, (*E*)-sabinene hydrate, (*Z*)-myroxide, δ-terpineol, γ-terpineol, *exo*-2-hydroxycineole acetate, β-copaene and (*E*)-sesquisabinene hydrate) were detected only in the essential oil of *O. basilicum*. These results are in a good agreement with those of most published studies on the chemical composition of *O. basilicum* essential oil in which linalool was found to be the predominant constituent: Kéita *et al.*[14] (69 %), Akgül[32] (45.7 %) and Gurbuz *et al.*[33] (41.2 %). In other studies, methyl chavicol (estragole) was represented as the major constituent in the *O. basilicum* leaf oils as can be seen in the study of Khatri *et al.*,[34] Telci *et al.*[10] and Chalchat *et al.*[28] Additionally, methyl eugenol was detected as the main component in *O. basilicum* leaf oil in Thailand by Suppakul *et al.*[29] These differences indicate that the chemical composition of the essential oils of *O. basilicum* varieties may be correlated with different environmental and ecological conditions, as well as by genetic factors.

The overall volatile constituents of the basil leaf oil samples were analyzed using the GC×GC technique. In this study, the conventional combination of columns BPX5/BP20 (Column set 1) and columns Solgel wax/BP1 (Column set 2) were also employed (Table I). The essential oil of *O. basilicum* leaves was used for the optimization of the conditions in both column sets due to the higher number of components identified by GC–MS than for the oil obtained from *O. basilicum* var. *thyrsiflora*. The resulting GC×GC–FID contour plots obtained by the two column sets for all samples are shown in Fig. 2. The component separation in the Column set 1 was based on boiling point and polarity in first and second columns, respectively, but the separation was the reverse in the Column set 2. As seen in the contour plots in Fig. 2, at least 101 and 87 individual components of *O. basilicum* leaf oils were resolved by the use of Column set 1 and 2 as shown in

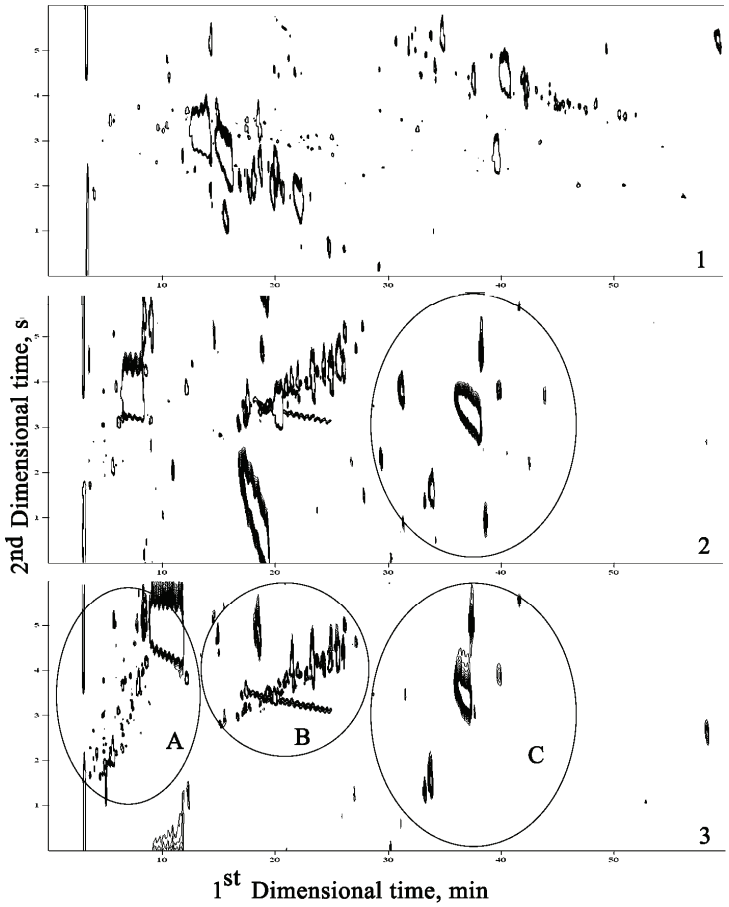

Fig. 2. The contour plots of the volatile component profiles of: 1) *O. basilicum* essential oil with the polar–non-polar column set, 2) *O. basilicum* essential oil with the non-polar-polar column set and 3) *O. basilicum* var. *thyrsiflora* essential oil with non-polar–polar column set. The components are grouped into 3 groups: monoterpenes (A), sesquiterpenes (B) and oxygenated sesquiterpenes (C).

Figs. 2(1) and 2(2), respectively. This indicates that a better resolution was achieved by the use of Column set 1, in which many overlapping peaks were resolved in the 2nd dimension, allowing additional volatile components to be detected. The differentiations of the chemical composition among two varieties by the Column set 1 are present as contour plots shown in Fig. 2(2) and 2(3), respectively. At least 92 and 101 volatile components were detected in *O. basilicum* var. *thyrsiflora* and *O. basilicum* leaf essential oil, respectively. Nevertheless, using GC×GC, more compounds were found and separated compared to those obtained by GC–MS. Grouping of the various components are highlighted in the circled areas: A includes the monoterpenes, B includes the sesquiterpenes, and C

includes the oxygenated sesquiterpenes. Although similar fingerprint patterns were exhibited in both essential oil profiles, the number of oxygenated monoterpenes (region A) of *O. basilicum* var. *thyrsiflora* essential oil was found to be significantly higher compared to that of the *O. basilicum* essential oil profile. The similar profiles of volatile sesquiterpenes (region B) in both essential oils are shown in Fig. 2(2) and 2(3), while numbers of oxygenated sesquiterpenes (region C) of *O. basilicum* essential oil were higher than that obtained from the essential oil of *O. basilicum var. thyrsiflora*.

The antioxidant activities of the essential oils of *O. basilicum* var. *thyrsiflora* and *O. basilicum* leaves were tested by DPPH radical scavenging. The violet color of the radical disappeared when mixed with the substances in the essential oil solution that can donate a hydrogen atom. The antioxidant activities of all the essential oils and eugenol are presented in Table III, in which lower IC_{50} values indicate higher antioxidant activity. The *O. basilicum* essential oil (IC_{50} = = 26.53±0.94 μg mL^{-1}) exhibited a higher scavenging ability for DPPH radicals than the essential oil of *O. basilicum* var. *thyrsiflora* (IC_{50} = 98.33±2.08 μg mL^{-1}). The other results show that a stronger antioxidant activity was found with standard linalool (IC_{50} = 0.61±0.05 μg mL^{-1}) and eugenol (IC_{50} = 2.83±0.08 μg mL^{-1}) than with either of the essential oils. Thus an essential oil containing a higher level of linalool and eugenol should provide a stronger antioxidant activity as was found by Jilisni and Simon[35] who reported that a stronger antioxidant activity was found in the essential oil containing a higher level of linalool. As a result, the *O. basilicum* essential oil was evaluated to be the stronger antioxidant than the essential oil of *O. basilicum* var. *thyrsiflora* according to the higher level of linalool and eugenol. The different levels of linalool and eugenol found between *O. basilicum* and *O. basilicum* var. *thyrsiflora* may be related to ecological conditions and genetic factors.

TABLE III. Antioxidant activities of basil essential oils, standard linalool and eugenol

Material	IC_{50} / μg mL^{-1} (DPPH)[a]	Total phenolic content[a] mg mL^{-1}
O. basilicum leaf oil	26.53±0.94	0.102±0.009
O. basilicum var. *thyrsiflora* leaf oil	98.33±2.08	0.070±0.004
Linalool	0.61±0.05	–[b]
Eugenol	2.83±0.08	–

[a]Values represent averages±standard deviations for triplicate experiments; [b]not studied

The amounts of total phenolic compounds in both the essential oils were investigated spectrometrically according to the Folin–Ciocalteu procedure, calculated as gallic acid equivalents. The essential oil of *O. basilicum* leaves contained higher amounts of total phenolic than that of *O. basilicum* var. *thyrsiflora* leaf oil, as can be seen in Table III. The total phenols of *O. basilicum* and *O. basilicum*

var. *thyrsiflora* essential oil are 0.102±0.009 and 0.070±0.004 mg mL^{-1}, respectively, at the same concentration of 5 mg mL^{-1}. In the present study, linalool (43.78 %) and eugenol (13.66 %), the major components in the essential oil of *O. basilicum*, would play an important role in the antioxidant activity. The low amounts of linalool (0.43 %) and eugenol (0.02 %) in *O. basilicum* var. *thyrsiflora* oil are reflected in its relatively low antioxidant activity.

CONCLUSIONS

Although the chemical compositions of the essential oils of *O. basilicum* var. *thyrsiflora* and *O. basilicum* leaves were similar, both oil samples had significant differences in their major constituents, as determined by GC–MS. In addition, GC×GC separation was utilized to monitor the profiles of both samples and good resolution was exhibited using a combination of non-polar and polar columns. Thus, this technique could be very useful for quality control during the industrial production of these essential oils. Finally, the high amount of linalool and eugenol in *O. basilicum* compared to *O. basilicum* var. *thyrsiflora* is likely responsible for the higher antioxidant activity of the former oil.

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ИЗВОД

ОДРЕЂИВАЊЕ ХЕМИЈСКОГ САСТАВА И АНТИОКСИДАТИВНЕ АКТИВНОСТИ БОСИЉКА ИЗ ТАЈЛАНДА ПРИМЕНОМ РЕТЕНЦИОНИХ ИНДЕКСА И ДВОДИМЕНЗИОНАЛНЕ ГАСНЕ ХРОМАТОГРАФИЈЕ

PATCHAREE PRIPDEEVECH[1], WATCHARAPONG CHUMPOLSRI[2], PANAWAN SUTTIARPORN[2] и SUGUNYA WONGPORNCHAI[2]

[1]*School of Science, Mae Fah Luang University, Chiang Rai, 57100 и* [2]*Department of Chemistry, Faculty of Science, Chiang Mai University, Chiang Mai, 50200, Thailand*

Хемијски састав етарског уља босиљка *Ocimum basilicum* var. *thyrsiflora* (1,39 % у односу на суву масу) и *Ocimum basilicum* (0,61 %) је анализиран методом GC–MS. Седамдесет три састојка, која чине 99,64% укупне површине испод хроматографских максимума, нађено је у уљу *O. basilicum* var. *thyrsiflora* и осамдесет (91,11 %) у уљу *O. basilicum*. Метил чавикол (81,82 %), *β*-(*E*)-оцимен (2,93 %) и *α*-(*E*)-бергамотен (2,45 %) су главни састојци уља *O. basilicum* var. *thyrsiflora*, док уље *O. basilicum* садржи највише линалола (43,78 %), еугенола (13,66 %) и 1,8-цинеола (10,18 %). Добро раздвајање испарљивих састојака у свим узорцима, постигнуто применом GC×GC, указује на значајну разлику у саставу две врсте босиљка. Антиоксидативна активност уља *O. basilicum* је велика, док је активност уља *O. basilicum* var. *thyrsiflora* мала. Разлика у активности потиче од значајне разлике у садржају линалола и еугенола у ова два етарска уља.

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