ANTIBACTERIAL ACTIVITIES AND CHEMICAL COMPOSITION OF ESSENTIAL OIL OF *BLUMEA BALSAMIFERA* (L.) DC., DISTRIBUTED IN LAMDONG PROVINCE, VIETNAM

Hoang Thi Binh[a*], Nguyen Minh Tri[a], Nguyen Huu Quan[a], Nguyen Van Ngoc[a]

[a] *The Faculty of Biology, Dalat University, Lamdong, Vietnam*
[*] *Corresponding author: Email: binhht@dlu.edu.vn*

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Abstract

In the present study, the chemical composition and the antibacterial properties of the essential oil obtained from fresh leaves of Blumea balsamifera (L.) DC. in Lamdong are reported. The hydrodistillation method was used to isolate essential oil from leaves of this species and gas chromatography/mass spectrometry (GC-MS) techniques were used to analyze the chemical constituents of the essential oil. Thirty six chemical constituents of the essential oil derived from fresh leaves of B. balsamifera were identified, in which the major compounds of the essential oil were camphor, caryophyllene, caryophyllene oxide, β-eudesmol, thymol hydroquinone dimethyl ether, and t-eudesmol, accounting for 43.69%, 12.71%, 5.98%, 4.84%, 4.63%, and 3.32%, respectively. Moreover, by using the agar well diffusion method, the antibacterial effects of B. balsamifera essential oilagainst Staphylococcus aureus and Escherichia coli were tested by the inhibition zone diameter test to evaluate the antibacterial activity.

Keywords: Antibacterial activity; *Blumea balsamifera*; Essential oil; Lamdong.

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THÀNH PHẦN HOÁ HỌC VÀ HOẠT TÍNH KHÁNG KHUẨN CỦA TINH DẦU *BLUMEA BALSAMIFERA* (L.) DC. PHÂN BỐ Ở LÂM ĐỒNG, VIỆT NAM

Hoàng Thị Bình[a*], Nguyễn Minh Trí[a], Nguyễn Hữu Quân[a], Nguyễn Văn Ngọc[a]

[a]*Khoa Sinh học, Trường Đại học Đà Lạt, Lâm Đồng, Việt Nam*
[*]*Tác giả liên hệ: Email: binhht@dlu.edu.vn*

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Tóm tắt

Trong nghiên cứu này, thành phần hoá học và hoạt tính kháng khuẩn của tinh dầu thu từ lá tươi loài Blumea balsamifera (L.) DC. phân bố ở Lâm Đồng, Việt Nam đã được công bố. Tinh dầu lá tươi của loài B. balsamifera (L.) DC. được thu nhận bằng phương pháp cất kéo hơi nước và được làm khan bằng Na_2SO_4*. Bằng phương pháp sắc ký khí ghép khối phổ (GC-MS) đã xác định được 36 thành phần hoá học có trong tinh dầu lá tươi loài B. balsamifera (L.) DC. ở Lâm Đồng, trong đó các hợp chất chính là camphor (43.69%), caryophyllene (12.71%), caryophyllene oxide (5.98%), β-eudesmol (4.84%), thymol hydroquinone dimethyl ether (4.63%), và t-eudesmol (3.32%). Bên cạnh đó, phương pháp khuếch tán giếng thạch cũng đã được sử dụng để đánh giá hoạt tính kháng khuẩn của tinh dầu này lên hai chủng vi sinh vật là Staphylococcus aureus và Escherichia coli, thông qua kích thước vòng kháng khuẩn cho thấy tinh dầu này có khả năng kháng cả hai chủng vi sinh vật thử nghiệm.*

Từ khóa: *Blumea balsamifera; Hoạt tính kháng khuẩn; Lâm Đồng; Tinh dầu.*

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Loại bài báo: Bài báo nghiên cứu gốc có bình duyệt

1. INTRODUCTION

Blumea DC. (1833) is a genus belonging to the Asteraceae family with approximately 100 species distributed throughout the Old World tropics (Anderberg, 1994, pp. 273-291; Anderberg & Eldenäs, 2007, pp. 374-390; Randeria, 1960). Almost all the species of the *Blumea* genus are widely distributed in tropical Asia with a few species in Australia and Africa (Anderberg, 1994, pp. 273-291; Anderberg & Eldenäs, 2007, pp. 374-390; Randeria, 1960). The genus is characterized by herbs, shrubs, or small trees; Stems not winged, with resin canals; Leaves alternate, simple, sessile or shortly petiolate, and mucronate-toothed to laciniate or sometimes pinnately lobed; Capitula heterogamous, disciform, solitary, or paniculate; Involucre campanulate-globose; Phyllaries numerous, imbricate, or reflexed in four or five series, outer series shortest; Marginal female florets in several rows, corolla yellow, filiform, and minutely 2- or 3-toothed (Shi et al., 2011).

According to Pham (2003) and Vo (2003), a total of 32 *Blumea* species are recorded and distributed throughout Vietnam, of which 10 species are reported from Lamdong province, including *Blumea adenophora, B. alata, B. balsamifera, B. densiflora var. hookeri, B. chevalierii, B. clarkei, B. fistulosa, B. hieracifolia var. hamiltonii, B. lacera,* and *B. virens* (Pham, 2003). In particular, *Blumea balsamifera* is widely distributed in many areas of Vietnam.

In ethnomedicine, *B. balsamifera* has anti-inflammatory, anticatarrhal, and expectorant effects, and has been used to treat asthmatic bronchitis and respiratory tract disorders (Chu, Du, & Liu, 2012). In traditional Vietnamese medicine, *B. balsamifera* leaves have been used to treat various diseases, such as fever, arthritis, and infective hepatitis (Do et al., 2004; Vo, 2003). To date, there have been many studies and reports about the chemical components in *Blumea balsamifera,* such as flavonoid compounds from leaves (Bui et al., 2017; Saewan, Koysomboon, & Chantraprommma, 2011) and components of essential oil from leaves of *B. balsamifera* grown in Bangladesh, China and Vietnam (Bhuiyan, Chowdhury, & Begum, 2009; Chu et al., 2012; Nguyen, Le, Nguyen, & Nguyen, 2004; Tran, Le, & Le, 2014). In Bangladesh, the chemical compositions of the essential oil from leaves of *B. balsamifera* were extracted with diethyl ether and the dominant components in the oil were borneol (33.22%), caryophyllene (8.24%), ledol (7.12%), tetracyclo[6,3,2,0,(2.5).0(1,8)]tridecan-9-ol, 4,4-dimethyl (5.18%), phytol (4.63%), caryophyllene oxide (4.07%), guaiol (3.44%), thujopsene-13 (4.42%), dimethoxy-durene (3.59%), and γ-eudesmol (3.18%) (Bhuiyan et al., 2009). In China, the main components of the essential oil of *B. balsamifera* obtained by hydrodistillation were 1,8-cineole (20.98%), borneol (11.99%), β-caryophyllene (10.38%), 4-terpineol (6.49%), α-terpineol (5.91%), and caryophyllene oxide (5.35%) (Chu et al., 2012). In Vietnam, chemical compositions of the essential oil from the leaves of *B. balsamifera* grown in Thuathienhue province obtained by hydrodistillation were reported by Tran et al. (2014). According to this report, borneol (40.33%), β-caryophyllene (26.51%), and thujopsene-13 (5.56%) were the dominant components in the essential oil. Chemical compositions of the essential oil of *B. balsamifera* leaves have been reported by Bhuiyan et al. (2009); Chu et al. (2012);

Nguyen et al. (2004); and Tran et al. (2014). However, the essential oil compositions may be affected by the choice of extraction methods. In addition, geographical variation also affects the composition of essential oils of plant species (Saei, Tajik, Moradi, & Khalighi, 2010). Moreover, until now there has been no report on the volatile constituents of essential oil composition as well as antibacterial activity of essential oil derived from the leaves of *B. balsamifera* distributed in Lamdong province. Thus, in this study, we report the chemical composition and the evaluation of antibacterial activity of the essential oil from the leaves of *B. balsamifera* distributed in Lamdong province.

2. MATERIALS AND METHODS

2.1. Plant materials

Fresh leaves of *Blumea balsamifera* L. (DC.) were collected in June to August, 2019 at altitudes of 1,800 m in Lan Tranh commune inside the protected area of Bidoup-Nui Ba National Park, Lamdong province, Vietnam. The specimens (voucher specimens: LD04) were deposited at the DLU Herbaria of Dalat University and the plant was identified based on type specimens, original descriptions, digitized plant specimen images available on the web at JSTOR Global Plants, and diagnostic traits described in the taxonomic literature (Pham, 2003; Vo, 2003).

2.2. Isolation of the essential oil

In the present study, the hydrodistillation method was used to extract essential oil from *B. balsamifera* leaves in Lamdong province. After the volatile essential oil was collected, sodium sulphate was used to dry the anhydrous essential oil of *B. balsamifera* and then the oil was kept at 4 ^{o}C until used for GC-MS analysis.

2.3. Gaschromatography-mass spectrometry (GC-MS) and identification of the constituents

The components of the essential oil derived from leaves of *B. balsamifera* were separated and identified using the gas chromatography-mass spectrometry (GC-MS) method. GC-MS analyses were conducted using a Thermo Scientific ISQ Single Quadrupole MS with the following specifications: Column: Agilent DB-5MS; Length: 30 m; Film: 0.25 μm; Diameter: 0.25 mm; MS transfer line temperature: 220 ^{o}C; Ion source temperature: 200 ^{o}C; Injector temperature: 220 ^{o}C; Temperature programmed: 70 ^{o}C (15 min) increase 10 ^{o}C/min up to 250 ^{o}C; Flow: 1.2 ml/min; and Mass range (m/z): 50-450. Most of the constituents of the essential oil were identified on the basis of retention times (RT). Further identification was carried out by comparison of their mass spectra with those stored in the NIST 08 and Wiley 275 libraries or with mass spectra from the literature (Adams, 2007).

2.4. Evaluation of antibacterial activity by the agar well diffusion method

In this study, two bacterial strains were identified and obtained from the Institute of Drug Quality Control in Hochiminh City, Vietnam. The bacterial strains used in this study were *Staphylococcus aureus* ATCC 6538 and *Escherichia coli* ATCC 8739. Nutrient agar (NA) was used to grow the two bacteria strains at 30 ^{o}C for 24 hours and the bacteria were then maintained on nutrient agar at 4 ^{o}C.

The antibacterial activity of the essential oil derived from fresh leaves of *B. balsamifera* was carried out by the agar well diffusion method (Devillers, Steiman, & Seigle, 1989; Valgas, Souza, Smania, & Smania, 2007). The bacteria were inoculated by the spread plate method on base plates containing 7 ml nutrient agar in sterile 9 cm Petri dishes (containing about 106-108 CFU/ml of the microorganisms). In the center of each dish, wells of approximately 6 mm diameter were created and 40 μL of essential oil solution, dimethyl sulphoxide (DMSO), and chloramphenicol were added to the wells. The sterile DMSO was used to the dilute essential oil of *B. balsamifera* to obtain four dilutions of 75%, 50%, 25%, and 12.5%, respectively. The chloramphenicol 250 mg (Vidipha Central Pharmaceutical Joint Stock Company, Vietnam) and the DMSO were used as a positive control and a negative control, respectively. The dishes were incubated at 4 ^{o}C for two hours for sample diffusion and then incubated at 30 ^{o}C for 24 hours. After that, the growth inhibition zones were measured and analyzed. In this study, each test was performed in triplicate.

2.5. Statistical analysis

Data analysis was performed using Microsoft Excel 2017. Mean values ± one standard deviation were calculated from triplicate determinations and used in the data presentation. Differences were considered significant at P <0.05 in the statistical analysis of the data.

3. RESULTS AND DISCUSSION

3.1. Chemical constituents of the essential oil

The steam distillation of *Blumea balsamifera* fresh leaves gave a yellowish essential oil with a very strong and pleasant odour. The results also showed that the yield of the essential oil of *B. balsamifera* fresh leaves was 0.16% (v/w) on a fresh weight basis. Thirty six compounds were identified in the essential oil of *B. balsamifera* leaves using GC-MS (Table 1 and Supplement 1).

Table 1. Chemical constituents of the essential oil of *Blumea balsamifera* fresh leaves

No.	Name of chemical constituents	RT	%
1	α-Pinene	5.06	0.58
2	Camphene	5.57	0.95
3	(+)-Sabinene	6.33	0.30

Note: "RT" stands for Retention times.

Table 1. Chemical constituents of the essential oil of *Blumea balsamifera* fresh leaves (cont.)

No.	Name of chemical constituents	RT	%
4	β-Pinene	6.54	1.37
5	β-Myrcene	6.94	0.20
6	o-Cymene	8.68	0.38
7	D-Limonene	8.97	2.60
8	5-Formal-4-nonene	9.11	0.15
9	*Trans*-β-ocimene	9.36	0.11
10	Cis-ocimene	10.04	0.93
11	τ-Terpinene	10.81	0.31
12	Filifolone	14.22	0.54
13	Linalool	14.42	0.51
14	2-Pinen-7-one	16.02	0.98
15	2-Methyl-2,4,6-octatriene	17.19	0.77
16	Camphor	17.56	43.69
17	Endo-borneol	18.46	2.14
18	β-Citral	20.45	0.23
19	α-Citral	21.15	0.58
20	Perillal	21.28	0.17
21	Silphiperfol-5-ene	22.34	0.41
22	7-Epi-silphiperfol-5-ene	22.69	0.74
23	Thymol hydroquinone dimethyl ether	23.80	4.63
24	Caryophyllene	23.99	12.71
25	Humulene	24.50	0.81
26	Aromadendrene	24.56	0.44
27	Elemol	25.74	0.66
28	Aristolene epoxide	25.80	0.29
29	(±)-*trans*-Nerolidol	25.86	0.84
30	β-Longipinene	26.10	0.53
31	Caryophyllene oxide	26.24	5.98
32	Guaiol	26.38	2.10
33	10-Epi-τ-eudesmol	26.73	2.24
34	τ-Eudesmol	26.83	3.32
35	Caryophylladienol II	26.88	1.98
36	β-Eudesmol	27.13	4.84

Note: "RT" stands for Retention times.

The results of the analysis showed that the essential oil of *B. balsamifera* fresh leaves mainly consisted of monoterpenes and sesquiterpenes. According to the results above (Table 1), the main components of the essential oil of *B. balsamifera* fresh leaves are camphor (43.69%), caryophyllene (12.71%), caryophyllene oxide (5.98%), β-eudesmol (4.84%), thymol hydroquinone dimethyl ether (4.63%), and τ-eudesmol (3.32%). Of these, camphor was determined to be the predominant compound in this essential oil. Camphor is a monoterpene and is known as a waxy, flammable, and transparent solid with a strong odour (Mann, Davidson, Hobbs, Banthorpe, & Harborne, 1994). This compound is used for many fields in human life as a pest deterrent and preservative, a popular perfume ingredient, in pharmaceutical applications, and so on (Ahmed, 2016; Donkin, 1999; Ghosh, 2000; MacKinney, Soti, Shrestha, & Basnyat, 2015). In medicine, camphor has antispasmodic, antipruritic, anti-inflammatory, anti-infective, activities, and has been used as a rubefacient, contraceptive, mild expectorant, nasal decongestant, cough suppressant, etc. (Segal, Cohen, & Freeman, 1978; Zuccarini, 2009). In addition, camphor has also been used to prevent and cure serious, life threatening diseases as a significant antioxidant and anti-tumor agent (Edris, 2007; Ho, Wang, & Su, 2009). The present results also show that caryophyllene and caryophyllene oxide are the second and third most dominant, respectively, in the essential oil of *B. balsamifera*, and they are members of bicyclic sesquiterpene. Their biological effects include anti-inflammatory, anticarcinogenic, antimicrobial, antioxidative, and analgesic activities (Klauke et al., 2014; Langhasova et al., 2014; Medeiros et al., 2007; Sabulal, Dan, Kurup, Pradeep, Valsamma, & George, 2006; Singh, Marimuthu, de Heluani, & Catalan, 2006). These two compounds have applications as cosmetics and food additives, and they also have a strong potential for use in medical applications due to their anticancer and analgesic properties (Fidyt, Fiedorowicz, Strządała, & Szumny, 2016). Therefore, the results of the present study may explain the use of *B. balsamifera* to treat various diseases in traditional medicine in Vietnam.

A comparison of the chemical composition between the essential oil of *B. balsamifera* leaves in this study and in previous studies is shown in Supplement 2. In the present study, camphor and caryophyllene are the dominant compounds in the essential oil of fresh *B. balsamifera* leaves, whereas 1,8-cineole and borneol were abundant compounds in the essential oil of *B. balsamifera* leaves reported in the previous studies of Bhuiyan et al. (2009); Chu et al. (2012); and Tran et al. (2014). According to the three previous reports, borneol was one of the main compounds of the essential oil of *B. balsamifera* leaves, but it was absent in this study. This issue is common because the quantity or quality of constituents in the essential oil of plant species may be influenced by the geographic variation (Saei et al., 2010; Sakee, Maneerat, Cushnie, & de Eknamkul, 2011).

3.2. Antibacterial activity of essential oil of *B. balsamifera* leaves

The assays for antibacterial activity against bacteria in the essential oil of *B. balsamifera* showed antibacterial activity against both Gram-positive and Gram-negative bacterial strains used in this study and expressed by the diameter of inhibition (Table 2).

Table 2. Antibacterial activity of essential oil derived from leaves of *B. balsamifera* in Lamdong province

Bacteria	Inhibition zone diameters (mm)						
	Chloramphenicol	DMSO	Concentration (% of essential oil in DMSO)				
			100%	75%	50%	25%	12.5%
E. coli	36.00 ± 4.00	-	12.00 ± 1.00	11.33 ± 0.57	8.33 ± 1.52	10.66 ± 1.52	7.00 ± 1.00
S. aureus	50.00 ± 2.00	-	12.70 ± 2.08	12.00 ± 1.73	11.50 ± 1.32	9.67 ± 2.08	8.16 ± 0.76

Note: “-” is not active.

The results revealed that the essential oil of *B. balsamifera* inhibited the growth of both *S. aureus* and *E. coli* at the different concentrations, in which the pure essential oil (the oil at 100% concentration) had the best inhibition zones, approximately 12 mm in diameter, for both *S. aureus* and *E. coli*. However, in this assay, the Gram-negative bacteria (*E. coli*) were generally less susceptible than Gram-positive bacteria (*S. aureus*) at all concentrations of essential oil because the outer membrane of Gram-negative bacteria is composed of hydrophilic lipopolysaccharides, and this structure creates a barrier toward macromolecules and hydrophobic compounds, providing Gram-negative bacteria with higher tolerance toward hydrophobic essential oil components (Trombetta et al., 2005). Additionally, comparison between the inhibition zone diameters in Table 2 and the suggestion of de Billerbeck (2007) about the classification of antibiotics on the basis of their inhibition diameters (Resistant: $D < 6$ mm; Intermediate: 13 mm $> D > 6$ mm; Sensitive: $D > 13$ mm) showed that both tested bacteria strains were not sensitive ($D > 13$ mm) to the essential oil of *B. balsamifera*, but two strains (*S. aureus* and *E. Coli*) of bacteria were moderately sensitive to the essential oil.

The activity against bacteria of the essential oil of *B. balsamifera* distributed in Lamdong Province is related to camphor (43.69%), the main component of the essential oil. Camphor is mainly responsible for the antibacterial activity of the plant oils which contain it, as it is known to have very efficient antibacterial properties (Jalsenjak, Peljnjak, & Kustrak, 1987; Sivropoulou et al., 1997). The result from this study may explain the use of *B. balsamifera* to treat various diseases in traditional medicine in Vietnam.

4. CONCLUSION

In conclusion, analysis by GC-MS showed that thirty six compounds were identified in the essential oil obtained from fresh leaves of *Blumea balsamifera* in Lamdong, Vietnam. Camphor (43.69%), caryophyllene (12.71%), caryophyllene oxide (5.98%), β-eudesmol (4.84%), thymol hydroquinone dimethyl ether (4.63%), and τ-eudesmol (3.32%) were the main components. In addition, the essential oil of this species showed significant antibacterial activity against both *E. coli* and *S. aureus* at different concentrations.

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