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CHEMICAL COMPOSITIONS OF ESSENTIAL OILS FROM THE LEAVES OF *Camellia pukhangensis* AND *C. quephongensis*

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There are over 280 species in the genus *Camellia*, most of which are found in Asia [1, 2]. The two countries with the most species are China and Vietnam [1]. *C. sinensis* (L.) Kuntze, *C. japonica* L., and *C. oleifera* Abel species have drawn much attention in studies on chemical compositions and biological activities because they are commercial products like tea and seed oils [1]. Alkaloids, steroids, terpenoids, saponins, and polyphenols were among the primary chemical classes found in *C. sinensis* [2]. *Camellia* plants have many pharmacological properties, including antioxidant, anticancer, antibacterial, and other health advantages, according to earlier studies [2].

It has also been recognized that *Camellia* species are a good resource of essential oils. One of the most extensively consumed beverages worldwide is tea (*C. sinensis* L.). The popularity of this beverage may be due to consumption to guard against specific human ailments. From GC-MS (gas chromatography-mass spectrometry) analysis, about 60 compounds were identified in the flower oil of Chinese *C. sinensis*, in which alkanes (45.4%), esters (10.5%), and ketones (7.1%) were the main phytochemical classes [3]. *C. nitidissima*, also known as yellow *Camellia*, has been recently used as a tea alternative [4]. Its leaf oil is reported to contain linalool (35.8%), phytol (7.9%), *cis*-geranyl acetone (7.3%), and methyl salicylate (6.8%), whereas its flower oil was dominated by α-eudesmol (34.3%), γ-eudesmol (31.5%), and linalool (11.1%) [4]. *C. tunghinensis* leaf oil has been associated with the presence of *n*-hexanal (17.2%), 2-pentylfuran (10.6%), phytone (7.5%), and geranylacetone (5.0%), while phytol (58%) was the main compound in *C. euphlebia* leaf oil [5].

Camellia pukhangensis N. D. Do, V. D. Luong, S. T. Hoang & T. H. Le, which was described as a new species in 2019, can be found available in central Vietnam [6]. In the meantime, *Camellia quephongensis* Hakoda ex Le, which was detected and named by Hakoda et al. in 2012–2013, is a perennial species of Hanh Dich, Thong Thu and Tien Phong of Nghe An Provinces, Vietnam [7]. To date, the essential oils of these two plants have not yet been investigated. In this article, we wish to report the chemical compositions of their leaf oils from fresh leaves collected in central Vietnam.

Hydro-distillation of *C. pukhangensis* fresh leaves resulted in a yellow essential oil with 0.1% yield, w/w. A total of 42 compounds were identified, representing 99.1% of the oil (Table 1). Oxygenated sesquiterpenes (49.5%), non-terpenic compounds (32.8%), and sesquiterpene hydrocarbons (14.2%) were the main phytochemical classes, while oxygenated diterpenes (1.9%), monoterpene hydrocarbons (0.4%), and oxygenated monoterpenes (0.3%) occasionally occurred. Benzyl benzoate (25.6%), cedrol (17.1%), (*E*)-nerolidol (12.1%), and β-selinene (5.3%) were the principal compounds, while other compounds, such as neocurdione (4.6%), α-cedrene (4.0%), and 7-*epi*-α-eudesmol (3.5%), were significant phytochemicals with percentages of more than 1.0%.

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TABLE 1. Essential Oils of Two Studied *Camellia* Leaves, %

Compound	RI	A	B	Compound	RI	A	B
α-Pinene	932	–	6.6	Longiborneol	1599	–	1.5
Camphene	946	–	2.7	Cedrol	1614	17.1	–
Methyl cyclohexyl ketone	963	–	2.1	2-(7*Z*)-Bisaboladien-4-ol	1620	0.3	–
β-Pinene	975	–	3.5	Junenol	1630	0.5	–
6-Methyl-5-hepten-2-one	987	0.3	–	1-*epi*-Cubenol	1638	1.0	–
β-Myrcene	990	–	3.6	β-Acorenol	1641	1.0	–
1,8-Cineole	1030	–	3.3	α-Cadinol	1655	1.3	5.0
Linalool	1099	–	2.8	Dihydroeudesmol	1661	0.7	–
Terpinolene	1101	0.1	–	7-*epi*-α-Eudesmol	1664	3.5	–
m-Anisaldehyde	1198	–	5.7	(*E*)-10,11-Dihydroatlantone	1673	–	2.9
(*E*)-Anethole	1288	1.0	–	*n*-Tetradecanol	1680	1.9	–
Capric acid	1367	–	2.6	Massoia dodecalactone	1691	1.3	–
α-Copaene	1382	0.3	–	Neocurdione	1698	4.6	–
cis-3-Hexenyl caproate	1390	0.3	–	(2*Z*,6*Z*)-Farnesol	1705	0.8	–
Methyl decyl ketone	1406	0.1	–	Curdione	1725	0.5	–
Decyl acetate	1411	0.7	–	(2*Z*,6*E*)-Farnesol	1728	1.0	–
α-Cedrene	1421	4.0	–	Benzyl benzoate	1764	25.6	1.0
β-Funebrene	1429	0.9	–	*n*-Pentadecanol	1778	–	1.6
(*E*)-Cinnamyl acetate	1448	0.3	–	*n*-Octadecane	1798	–	1.2
Neryl propanoate	1462	0.3	–	Hexadecanal	1815	–	0.3
γ-Muurolene	1483	0.5	–	Cyclopentadecanolide	1838	–	2.9
ar-Curcumene	1487	0.3	–	Hexahydrofarnesyl acetone	1844	2.0	24.8
β-Selinene	1495	5.3	–	*trans*-Phytol	1947	1.9	3.1
α-Selinene	1503	1.8	–	(*E*,*E*)-Geranyl linalool	2029	–	1.8
α-Muurolene	1507	0.2	–	*cis*-Phytol	2112	–	8.5
(*E*,*E*)-α-Farnesene	1508	–	3.3	Linoleic acid ethyl ester	2142	–	4.5
β-Bisabolene	1514	0.7	–	Hexadecanal diallyl acetal	2146	1.2	–
δ-Amorphene	1522	0.3	–	Total		99.1	100
trans-Calamenene	1530	0.2	–	Monoterpene hydrocarbons		0.4	16.4
Elemol	1557	0.3	–	Oxygenated monoterpenes		0.3	6.1
(*E*)-Nerolidol	1568	12.1	–	Sesquiterpene hydrocarbons		14.2	3.3
cis-3-Hexenyl benzoate	1576	0.1	–	Oxygenated sesquiterpenes		49.5	38.9
Spathulenol	1578	–	4.7	Oxygenated diterpenes		1.9	13.4
(*Z*)-Dihydroapofarnesol	1579	0.7	–	Non-terpenic compounds		32.8	21.9
Caryophyllene oxide	1594	2.1	–				

A – *C. pukhangensis*; B – *C. quephongensis*

RI: Retention indices relative to *n*-alkanes (C_7–C_{40}) on Equity-5 column, bold: major compound.

The leaf oil of the second plant was associated with the presence of 24 identified compounds and accounted for 100% (Table 1). Oxygenated sesquiterpenes (38.9%), non-terpenic compounds (21.9%), monoterpene hydrocarbons (16.4%), and oxygenated diterpenes (13.4%) are possibly the main phytochemical classes where two remaining classes oxygenated monoterpenes and sesquiterpene hydrocarbons at 6.1 and 3.3%, respectively. *C. quephongensis* leaf oil was predominant with hexahydrofarnesyl acetone (24.8%), *cis*-phytol (8.5%), α-pinene (6.6%), *m*-anisaldehyde (5.7%), and α-cadinol (5.0%). From Table 1, the remaining compounds were also significant with percentages of more than 1.0%, except for hexadecanal (0.3%).

There has been a drastic difference in the number of phytochemical classes between the two studied oils. In addition, numerous compounds were only observed in one sample and *vice versa* – for instance, the major compounds of *C. pukhangensis* leaf oil were present as minor ones or completely absent in *C. quephongensis* leaf oil. Remarkably, two major compounds, benzyl benzoate and hexahydrofarnesyl acetone, are now abundant in the essential oils of many terrestrial plants, but they did not reach high amounts in *Camellia* essential oils. Hence, two Vietnamese *Camellia* species – *C. pukhangensis* and *C. quephongensis* – are likely to be good resources of benzyl benzoate and hexahydrofarnesyl acetone, respectively.

Materials. The fresh leaves of *C. pukhangensis* were collected from Nga My, Tuong Duong, Nghe An, Vietnam (19°15′46″ N and 104°18′18″ E) in August 2022. In the meantime, the fresh leaves of *C. quephongensis* were gathered from Hanh Dich, Que Phong, Nghe An, Vietnam (19°40′4″ N and 105°55′30″ E) in April 2022.

Hydro-distillation Procedure. The fresh leaves of each plant (1.0 kg) were hydro-distilled using a Clevenger apparatus with clean water for 2.5 h, to give yellow oils (0.1% and 0.13% for *C. pukhangensis* and *C. quephongensis*, respectively). The obtained oils were dried over anhydrous Na_2SO_4 before analysis.

The GC/FID-MS Analysis. The procedure was the same as in our previous reports [8–10].

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