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Linalool-Rich Essential Oil of *Phlomis Bracteosa* from Garhwal Himalaya: Composition and Potential Applications

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Abstract: *Phlomis bracteosa* Royle ex. Benth, an aromatic herb native to the Garhwal region of the Uttarakhand Himalayas, has been recognized for its essential oil composition, particularly its high volatile content. The aerial parts of *Phlomis bracteosa* Royle ex Benth. were collected from Gangi village (Tehri Garhwal District) of Uttarakhand, India. After the aerial pieces were steam-distilled, a light green oil was produced. By using GC and GC-MS to identify over 30 chemicals, the essential oil composition was ascertained. Linalool was found to be the most abundant oxygenated monoterpene, while (E)-caryophyllene and germacrene D represented the sesquiterpene hydrocarbons. Oxygenated sesquiterpenoids were noticed in smaller amounts. This study explores the phytochemical profile and potential therapeutic applications of the essential oil derived from this plant. The research also examines the ecological significance and sustainable utilization of *Phlomis bracteosa* in traditional and modern medicine.

Keywords: *Phlomis* • Lamiaceae • Linalool, Limonene • *(E)-C*aryophyllene • Germacrene D

Introduction

The use of medicinal plants in traditional healing practices has been well-documented, particularly in the Himalayan region (Kumar *et al.* 2019). *Phlomis bracteosa*, belonging to the Lamiaceae family, is known for its diverse bioactive compounds. Essential oils extracted from *Phlomis bracteosa* are known to possess bioactive constituents with significant therapeutic relevance. Among these, linalool stands out due to its notable antimicrobial and anti-inflammatory characteristics. The genus *Phlomis*, primarily distributed across Asia and the Mediterranean, comprises numerous species used in folk medicine for various ailments such as ulcers, inflammation, and infections. Prior phytochemical research has identified key constituents including diterpenoid glycosides, flavonoids, and iridoids. (Dhiman *et al.* 2020, Prakash *et al.* 2011, Rios *et al.* 2005). It is an erect herb with shortly stalked leaves and pink flowers. It consists of about 80 species of annual or perennial herbs, sometimes shurbs, distributed in the tropics of Asia, Africa and Australia. The genus is eminently characteristic of India where about 35 species occur (Gupta, 1989). Different classes of chemical compounds like glycosides containing diterpenoids, iridoids, phenylpropanoids, phenylethanoids and flavonoids have been identified from *Phlomis* (Saracoglu *et al.* 1998, Sarkhail *et al.* 2003). Some species of *Phlomis* are used in folk medicine as stimulants, tonics, diuretics and for the treatment of ulcers (Saracoglu *et al.* 1998). Many activities, including anti-inflammatory, immunosuppressive, antimutagenic, anti-ociceptive, antifibriel, free radical scavenging, anti-allergic, anti-malarial, and antimicrobial properties, are reported. (Sarkhail *et al.* 2003, Kirmizibekmez *et al.* 2005, Katagiri *et al.* 1994, Kyriakopoulo *et al.* 2001, Shin *et al.* 2003, Kirmizibekmez *et al.* 2004, Couldis *et al.* 2000, Kamel *et al.* 2000,

Betül *et al.* 2003, Parisa *et al.* 2006, Joshi *et al.* 2010, Javid *et al.* 2011, Ullah *et al.* 2015) for different species of this plant. This study aims to analyze the phytochemical constituents, extraction methods, and therapeutic potential of the linalool-rich essential oil obtained from *Phlomis bracteosa* collected from Garhwal Himalayan Region of Uttarakhand.

Plant materials

Phlomis bracteosa's fresh flowering aerial parts were gathered from Gangi village, which is 2465 meters above sea level and located in Uttarakhand's Tehri Garhwal region. A plant herbarium was identified from Kumaun University Nainital's Department of Botany, and a voucher specimen was placed in the Chemistry Department's Phytochemistry Laboratory.

Fig.1. Phlomis bracteosa

Material and Methods

Extraction of oils

The newly collected aerial sections (1.5 kg of the plant) underwent steam distillation with an electric copper still. The distillates were infused with NaCl, and the oils were separated using hexane and CH2Cl2. The organic layer was dried with Na2SO4, and the solvent was evaporated at 30 °C.

Isolation of major constituents

By fractionating the essential oil on a silica gel column chromatography (230-400 mesh, Merck, 600 × 25 cm column) packed with hexane and employing Et2O-hexane as a mobile phase while progressively increasing the amount of ether (2–10%), the principal chemicals were separated. The identification process was based on the following criteria: co-injection with standard (Sigma), MS Library search (NIST and WILEY), comparison with MS literature data (Adams, 1995, Adams, 2001), NMR (1H, 13C NMR) of major isolates, and Linear Retention Index (LRI, calculated concerning homologous series of n-alkanes (C9-C24, Polyscience Corp., Niles IL under identical experimental conditions). Without a correction factor, the relative amounts of each component were determined using the GC peak area (FID response).

GC and GC-MS analysis

The essential oil sample was examined using a Nucon 5765 gas chromatograph, fitted with an Rtx-5 non-polar fused silica capillary column (30 m × 0.32 mm, with a film thickness of 0.25 µm). The oven temperature was programmed to rise from 60 to 210°C at 3°C per minute, utilizing nitrogen as the carrier gas at a pressure of 4 Kg cm-2. The injector and detector temperatures were maintained at 210°C, with an injection volume of 0.5 mL, using a 10% oil solution in n-hexane. For the GC-MS analysis, a ThermoQuest Trace GC 2000 was linked to a Finnigan MAT PolarisQ ion trap mass spectrometer, also equipped with an Rtx-5 non-polar fused silica capillary column (30 m × 0.25 mm and a 0.25 µm film thickness). The oven temperature was programmed similarly from 60 to 210°C at 3°C per minute, using helium as the carrier gas at a flow rate of 1.0 min-1. The temperatures for the injection port, ion source, and MS transfer line were set to 210°C, 220°C, and 275°C, respectively, with an injection volume of 0.1 mL and a split ratio of 1:40. The mass spectrometry measurements were conducted at 70 eV across a mass range of 40 to 450 amu.

Results and discussion

GC and GC-MS analysis revealed 33 components in all, which made up 99.1% of the oil. Linalool (39.6%), limonene (3.5%), (E)-caryophyllene (20.4%), and germacrene D

(11.6%) were the main constituents of the essential oil **(Table1, Fig.2)**.

Table1. Constituents of *P. bracteosa* Royle ex Benth.

S. No.	Compounds	RT	LRI_R	LRI	FID %	Mode of Identification
1	α-thujene	5.62	924	933	0.6	a, b
2	α-pinene	5.85	932	941	1.1	a, b
3	Sabinene	6.91	969	978	1.4	a, b
4	β- pinene	7.04	974	982	3.1	a, b
5	α-phellandrene	7.85	1002	1009	0.7	a, b
6	α-terpinene	8.3	1014	1019	0.9	a, b
7	p-cymene	8.53	1020	1029	0.6	a, b
8	β- phellandrene	8.7	1025	1032	0.5	a, b
9	Limonene	8.69	1024	1033	3.5	a, b
10	(Z)- β-Ocimene	8.96	1032	1042	t	a, b
11	(E)- β-Ocimene	9.42	1044	1051	t	a, b
12	**Linalool**	**11.32**	**1095**	**1100**	**39.6**	**a, b**
13	Chrysanthemone	12.53	1124	1120	0.5	a, b
14	Borneol	14.29	1165	1167	0.7	a, b
15	terpinen 4-ol	14.66	1174	1180	t	a, b
16	carvacrol methyl ether	17.61	1241	1236	0.3	a, b
17	Geraniol	17.95	1249	1256	0.2	a, b
18	Piperitone	17.99	1255	1263	0.1	a, b
19	bornyl acetate	19.62	1287	1285	0.2	a, b
20	Thymol	19.71	1289	1294	1.8	a, b
21	Carvacrol	20.14	1298	1310	0.6	a, b
22	δ- elemene	21.77	1335	1339	2.3	a, b
23	α- longipinene	22.41	1350	1350	0.5	a, b
24	α- cubebene	24.05	1387	1357	t	a, b
25	**β-caryophyllene**	**25.36**	**1417**	**1418**	**20.4**	**a, b**
26	α-humulene	26.82	1452	1454	4.3	a, b
27	β -chamigrene	27.82	1476	1463	0.2	a, b
28	**germacrene D**	**28.15**	**1484**	**1480**	**11.6**	**a, b**
29	ar-curcumene	28.5	1485	1485	0.4	a, b
30	Valencene	28.66	1496	1498	0.2	a, b
31	δ-cadinene	29.72	1522	1524	0.4	a, b
32	Cubenol	34.63	1645	1647	t	a, b
33	β-eudesmol	34.79	1649	1651	2.4	a, b
	Total Identified %				**99.1**	
	Monoterpene Hydrocarbons %				12.4	
	Oxygenated Monoterpenes %				**46.8**	
	Sesquiterpene Hydrocarbons %				37.5	
	Oxygenated Sesquiterpenes %				2.4	

Mode of identification a= linear retention indices (LRI) determined with reference to homologous series of *n*-alkanes (C_9-C_{24}),co-injection with standards, b= MS Library search (NIST and WILLEY), MS literature data. Bold type indicates major components (Biochemical marker s). LRI_R : Linear retention index Reported in literature, LRI: Linear retention index on Rtx-5 column

75.9% sesquiterpenes and a tiny amount of monoterpenes were previously found in *P. olivieri* essential oil, which was dominated by the presence of hexahydro farnesyl acetone (Ghassemi et al. 2001, Sokovic et al. 2002). β-caryophyllene, (E)-methyl-isoeugenol, α-asarone, caryophyllene oxide, and α-pinene were the main constituents of the essential oil that was extracted from *P. fruticosa leaves (Celik et al. 2005).*

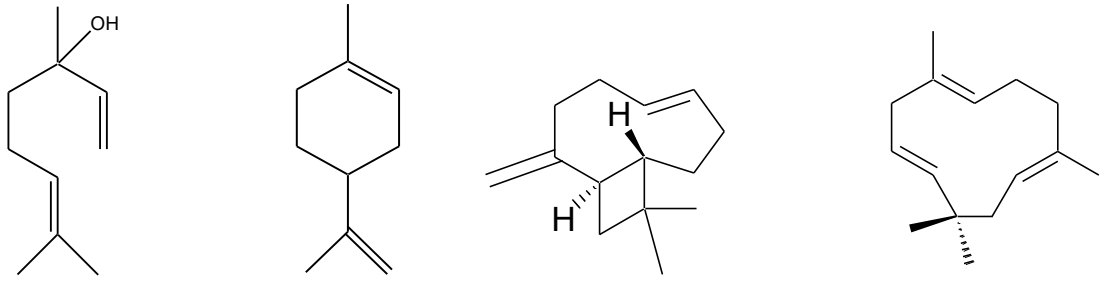

Fig.2. Structure of the major components of *P. bracteosa*

The primary constituents of *P. leucophracta's* essential oil were limonene, α-pinene, and β-caryophyllene. Meanwhile, β-caryophyllene and linalool were the primary molecules in *P. chimerae*, while germacrene D, β-caryophyllene, and bicyclogermacrene were found to be among the most prevalent components in *P. grandiflora* (Tsitsimi et al. 2000). Germacrene D-rich essential oil was extracted from *P. fruticosa's* floral parts (Aligiannis et al. 2004). In a different investigation, the primary components of the essential oil extracted from *P. fruticosa* aerial parts gathered in Peloponnesus were linalool, α-pinene, β-caryophyllene, and germacrene D. In the same study, the volatile components of two more *Phlomis* species—*P. cretica* and *P. samia*—were investigated. α-pinene, limonene, *cis-β*-ocimene, linalool, *β*-caryophyllene, and germacrene D were the main constituents of *P. cretica*. Large levels of β-caryophyllene, germacrene D, and linalool were identified in *P. samia*, although *(E)-β*-farnesene was the main component. (Betül *et al.* 2003, Parisa *et al.* 2006, Guy *et al.* 2008). In our study, we found linalool rich (**39.6%**) essential oil of *P. bracteosa* which makes it different from other previously studied species all over the world. 60% to 80% of scented cleaning products and hygiene products, such as soaps, detergents, shampoos, and lotions, contain linalool as an ingredient. It has antifungal and antibacterial qualities. Furthermore, linalool is utilized as an insecticide to combat cockroaches, fleas, and fruit flies (Guy *et al.* 2008). The traditional use of *Phlomis bracteosa* includes its application in treating skin infections, digestive disorders, and respiratory ailments. In modern applications, the essential oil is used in: **Aromatherapy:** As a natural relaxant and mood enhancer, **Cosmetic Industry:** Incorporated into skincare products due to its anti-aging and antimicrobial properties and in **Pharmaceuticals:** Investigated for its potential role in developing new herbal medicines (Parisa *et al.* 2006, Guy *et al.* 2008). Further studies are required to Conduct clinical trials to validate pharmacological claims, explore novel formulations incorporating *Phlomis bracteosa* essential oil and investigate potential synergistic effects with other medicinal plant extracts.

Conclusion

The essential oil of *Phlomis bracteosa*, which is rich in linalool, holds significant promise in both traditional and modern medicinal applications. Linalool, a naturally occurring terpene alcohol found in many aromatic plants, is well known for its diverse pharmacological properties, including antimicrobial, anti-

inflammatory, antioxidant, and analgesic effects. These therapeutic benefits make *Phlomis bracteosa* an important candidate for further scientific exploration, particularly in the fields of natural medicine, pharmaceutical development, and holistic healthcare.

Traditionally, the plant has been utilized for its medicinal properties in various cultures, often as a remedy for ailments such as respiratory infections, digestive disorders, and inflammatory conditions. Modern research has begun to validate these uses, demonstrating that linalool-rich essential oils possess strong bioactive potential that could be harnessed for the development of new, plant-based therapeutic agents. Additionally, the calming and neuroprotective effects of linalool make it a valuable component in aromatherapy and stress-relief treatments, further expanding its scope of application.

Beyond its medicinal benefits, the sustainable utilization of *Phlomis bracteosa* is crucial for ensuring long-term availability while preserving biodiversity. Cultivation and responsible harvesting of the plant can contribute to environmental conservation efforts, reducing the pressure on wild populations and promoting ecological balance. By integrating traditional knowledge with modern scientific advancements, researchers and healthcare practitioners can unlock the full potential of this valuable plant, leading to innovative solutions for both human health and environmental sustainability.

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