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Review Article

Blumea malcolmii Hook.f. (Asteraceae): A Comprehensive Review of Taxonomy, Phytochemistry, Ethnobotany, And Pharmacological Potential

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ABSTRACT

Blumea malcolmii Hook.f. is a small, woolly annual or perennial herb endemic to India. Despite the isolation and structural characterization of phytoconstituents, it remains one of the most therapeutically underexplored members of the genus Blumea DC. This review consolidates all available species-specific and genus-level evidence through a systematic, synonym-based literature search using the accepted species name and all five recorded synonyms, retrieving 51 primary and secondary sources spanning 1876–2026. The essential oil was first investigated in 1922 and definitively reinvestigated in 2016 using GC-FID and GC-MS, confirming carvotanacetone as the dominant constituent (92.1% of 18 identified compounds). Four quercetagetin methyl ethers were isolated and their structures corrected by Markham (1989). To date, no in vitro or in vivo therapeutic pharmacological studies have been published for B. malcolmii. This review highlights critical research gaps and proposes a structured, prioritized research agenda focusing on carvotanacetone bioassays and in silico molecular docking of the four quercetagetin methyl ethers.

INTRODUCTION

The family Asteraceae (Compositae), comprising approximately 1,600–1,700 genera and 24,000–30,000 species, is one of the largest and most evolutionarily successful families of angiosperms.[1] Within Asteraceae, the tribe Inuleae Cass. is distinguished by tailed (caudate) anthers, cypsela walls containing large calcium oxalate crystals in individual epidermal cells, and a predominantly paleotropical distribution.[2,3,4,5] *Blumea* DC. is the largest genus within Inuleae, consisting of around 100 species of annual or perennial herbs and shrubs distributed across tropical and subtropical regions of Asia, Africa, and Australia. The genus was established by De Candolle (1833) and is morphologically characterized by disciform capitula comprising

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outer filiform female florets and inner tubular bisexual florets, together with the distinctive cypsela anatomy that provides genus-level diagnostic characters.[2,3]

Many *Blumea* species are deeply integrated into traditional medicine systems, particularly in Asia. *Blumea balsamifera* (L.) DC. ('sambong') is the most extensively studied member of the genus, with documented antitumour, hepatoprotective, antioxidant, antimicrobial, anti-inflammatory, antiplasmodial, wound healing, and anti-obesity activities.[6,7] *Blumea lacera* (Burm.f.) DC. ('kakronda') has been reviewed for anti-inflammatory, anthelmintic, antidiarrheal, antimicrobial, hepatoprotective, and analgesic properties.[8] These well-investigated congeners highlight the therapeutic potential of *Blumea* species and reflect the neglect of less-studied species in the same genus.

In contrast to *B. balsamifera* and *B. lacera*, a substantial proportion of *Blumea* species remain scientifically underexplored despite ethnobotanical relevance and documented phytochemical constituents. *Blumea malcolmii* (C.B.Clarke) Hook.f. exemplifies this gap. Originally described by C.B.Clarke as *Pluchea malcolmii* in *Compositae Indicae*,[9] the species is now accepted as *B. malcolmii* with five recorded synonyms listed in Plants of the World Online (POWO) and World Flora Online.[10,11] The indexed scientific literature directly pertaining to *B. malcolmii* is limited to eight primary outputs: characterization of its essential oil,[12] isolation of four 6-hydroxyflavonols,[13] structural correction of those isolates as quercetagetin methyl ethers,[14] GC-FID/GC-MS reinvestigation of the essential oil confirming carvotanacetone as the dominant constituent,[15] phytoremediation of the sulfonated azo dye Direct Red 5B using cell suspension cultures,[16] phytodegradation of the triphenylmethane dye Malachite Green by cell cultures,[17] detoxification of a carcinogenic paint preservative by cell cultures,[18] and pharmacognostic and phytochemical evaluation of leaf material.[19] No *in vitro* or *in vivo* therapeutic pharmacological investigation has yet been published for *B. malcolmii*.

The present review addresses this critical gap by consolidating all available species-specific and genus-level evidence for *B. malcolmii* through a methodologically rigorous, synonym-based bibliometric search strategy. By integrating taxonomic, pharmacognostic, phytochemical, ethnobotanical, and congener-derived pharmacological data, this review provides the first comprehensive synthesis for *B. malcolmii*, highlights key research gaps, and proposes a structured, prioritized research agenda with particular emphasis on carvotanacetone and the four quercetagetin methyl ethers as rational starting points for systematic bioassay-guided evaluation.

LITERATURE SEARCH METHODOLOGY

A comprehensive, synonym-based literature search was conducted across PubMed, Scopus, Web of Science, Google Scholar, NISCAIR Open Access Journals, and Shodhganga (Indian thesis repository). Primary search terms included "*Blumea malcolmii*", "Panjrut", "carvotanacetone *Blumea*", and "quercetagetin methyl ether *Blumea*". Synonym-based terms covered all five recorded POWO synonyms:[10] "*Pluchea malcolmii*", "*Pluchea lanuginosa*", "*Placus lanuginosus*", "*Blumea lanuginosa*", and "*Blumea lanuginosa (Hook.f.) T.Cooke ex M.R.Almeida*". Genus-level searches used "*Blumea* phytochemistry", "*Blumea* pharmacology", and "genus *Blumea* review". No date restrictions were applied; historical literature including pre-1900 and early twentieth-century chemical articles was

retrieved from archival repositories. Synonym-based searching was essential to bibliometric completeness, preventing the exclusion of articles indexed under synonym names rather than the currently accepted binomial.[20]

TAXONOMY, NOMENCLATURE, AND GEOGRAPHICAL DISTRIBUTION

Taxonomic Classification

The full accepted taxonomic classification of *B. malcolmii* is presented in Table 1.

Table 1: Taxonomic classification of Blumea malcolmii (C.B.Clarke) Hook.f.

Rank	Classification
Kingdom	Plantae
Phylum	Streptophyta
Class	Equisetopsida C.C.Agardh
Subclass	Magnoliidae
Order	Asterales
Family	Asteraceae
Tribe	Inuleae Cass.
Genus	Blumea DC.
Species	*Blumea malcolmii (C.B.Clarke) Hook.f.*
Sources: POWO, Royal Botanic Gardens Kew (2026);[10] World Flora Online (2026).[11]	

The tribe Inuleae is distinguished from other Asteraceae tribes by tailed (caudate) anthers, cypsela walls with large calcium oxalate crystals in individual epidermal cells, and a predominantly paleotropical distribution.[4,5] Within Inuleae, *Blumea* is the largest genus and is further defined by its disciform capitulum structure.[2]

Nomenclatural History and Accepted Synonymy

The earliest valid nomenclatural record for this taxon is C.B.Clarke's description as *Pluchea malcolmii* in *Compositae Indicae* (1876).[9] The synonym epithet *lanuginosa* (Latin: woolly) directly references the plant's defining morphological character – its conspicuous lanate indumentum, and was applied independently by multiple authors across several synonymous combinations, reflecting the species' most visually distinctive feature.[21] The five currently recorded synonyms, as recognized by POWO and World Flora Online, are presented in Table 2.[10,11]

Table 2: Accepted synonyms of Blumea malcolmii (C.B.Clarke) Hook.f.

Synonym	Published in	Year	Nomenclatural status
Pluchea malcolmii C.B.Clarke	Compos. Ind.: 95	1876	Basionym; *nom. legit.* (nomen legitimum)
Pluchea lanuginosa Hook.f.	Fl. Brit. India 3: 266	1881	Validly published synonym
Placus lanuginosus (Hook.f.) Kuntze	Revis. Gen. Pl. 1: 357	1891	Validly published synonym
Blumea lanuginosa Law ex Cooke	Fl. Bombay 2: 23	1904	*nom. inval.* (nomen invalidum)
Blumea lanuginosa (Hook.f.) T.Cooke ex M.R.Almeida	Fl. Maharashtra 3A: 81	2001	*nom. illeg.* (nomen illegitimum)
Sources: POWO (Kew, 2026);[10] WFO (2026).[11] *(nom. legit. = nomen legitimum (name validly published and nomenclaturally legitimate); nom. inval. = nomen invalidum (name not validly published under ICN rules); nom. illeg. = nomen illegitimum (name validly published but nomenclaturally illegitimate due to incorrect basionym attribution))*			

The synonym *B. lanuginosa* (Almeida, 2001),[22] carries an incorrect basionym attribution – a nomenclatural error that has propagated through the regional floristic literature of Maharashtra and may have contributed to the species being overlooked in database-based literature searches. All future studies must consistently use the accepted binomial *Blumea malcolmii* (C.B.Clarke) Hook.f. as required by the International Code of

Nomenclature for algae, fungi, and plants (ICN) (Shenzhen Code, 2018).

Geographical Distribution and Ecology

B. malcolmii is endemic to India. Its confirmed distribution spans five states based on multiple authoritative taxonomic and floristic sources (Table 3).

Table 3: Confirmed distribution of Blumea malcolmii (C.B.Clarke) Hook.f. in India

State	Specific Localities	Ref.
Maharashtra	Kolhapur, Pune, Raigad, Ratnagiri, Satara, Thane	22, 23
Karnataka	South Kanara (Dakshina Kannada); Western Ghats	15, 23
Kerala	Idukki	23
Tamil Nadu	Dindigul	23

The species grows primarily along moist deciduous forest margins and seasonally dry open habitats of the Western Ghats, occurring on hill slopes, open exposed areas, roadsides, and scrublands within grassy matrices at low to moderate altitudes.[15,19,22,23] No comprehensive population survey, ecological assessment, or IUCN Red List evaluation has been conducted for *B. malcolmii*, constituting a gap in conservation biology documentation.

BOTANICAL DESCRIPTION AND PHARMACOGNOSY

Macroscopic Morphology

B. malcolmii (C.B.Clarke) Hook.f. is a small annual or perennial herb, erect or partially decumbent. Key findings include:[9,15,19]

1. **Stem:** Herbaceous, cylindrical to sub-angular in cross-section, densely clothed with rough, woolly (lanate) indumentum comprising multi-cellular glandular (capitate) and eglandular (simple uniseriate) trichomes. This dense indumentum is the most visually prominent diagnostic character of the species and is the etymological basis for the historical *lanuginosa* epithets throughout its synonymy.[9,19]

2. **Leaves:** Simple, alternate, sessile to sub-sessile; lamina with woolly (lanate) pubescence on both adaxial and abaxial surfaces, more pronounced abaxially. Margins dentate to crenate-dentate. Leaf base auriculate and amplexicaul (clasping the stem)..[19]

3. **Inflorescence:** Paniculate cymes bearing disciform capitula. Involucre multi-seriate, phyllaries linear. [9,19]

4. **Florets:** Outer florets filiform (thread-like), pistillate, arranged in multiple outer rows. Inner disc florets tubular, yellow, bisexual, with characteristically tailed (caudate) anthers – the tribal diagnostic character of Inuleae.[2,3]

5. **Fruit (Cypsela):** Ribbed longitudinally, bearing a pappus; cypsela wall epidermal cells each contain a single large calcium oxalate crystal – a genus-level diagnostic microscopic character.[3]

6. **General habit:** A small annual (sometimes perennial), densely white-woolly throughout, occurring on hill slopes, open exposed areas, and roadsides amidst grasses.[15]

Microscopic Anatomy

Suryawanshi et al. (2021)[19] conducted a systematic pharmacognostic study of *B. malcolmii* leaf material at the microscopic level. Key findings include:

1. **Epidermis:** Both adaxial and abaxial epidermis bear abundant trichomes. Glandular (capitate) trichomes are secretory and

functionally associated with the essential oil fraction. Stomata are anomocytic type, consistent with herbaceous Asteraceae.[19]

2. **Mesophyll:** Dorsiventral organization, with palisade parenchyma beneath the adaxial epidermis and loosely arranged spongy parenchyma comprising the abaxial mesophyll. Calcium oxalate crystal clusters (druses) are present within mesophyll cells, consistent with the family-level Asteraceae character. [19]

3. **Vascular tissue:** Collateral, closed vascular bundles in the stem, arranged in a ring in transverse section. Vascular architecture is typical of herbaceous Asteraceae.[19]

4. **Powder microscopy:** Diagnostically significant features include abundant trichome fragments (both glandular and non-glandular types), calcium oxalate crystal aggregates, and pollen grains with characteristic surface sculpturing. [19,24]

Pharmacognostic Parameters

Physicochemical constants for leaf material – including loss on drying, total ash, acid-insoluble ash, water-soluble ash, and alcohol-soluble and water-soluble extractive values– have been determined by Suryawanshi et al. (2021).[19] These parameters have not been extended to stem, root, flower, or seed material, and interlaboratory reproducibility of the reported values has not been established. Pharmacognostic profiling of multiple plant parts is a prerequisite for complete standardization prior to quality control specification or regulatory submission.

ETHNOBOTANY AND TRADITIONAL USES

Documented Ethnobotanical Uses of *B. malcolmii*

The ethnobotanical documentation of *B. malcolmii* is limited to a single primary record. Suryawanshi et al. (2021)[19] document that the plant, known as 'Panjrut' in Marathi, is employed in folkloric medicine principally for wound healing in tribal and rural communities of Maharashtra. Joshi and Pai (2016)15 also record the vernacular name 'Panjrut' and describe the species' habitat in the Western Ghats region of Karnataka, extending the documented distribution beyond Maharashtra. The specific plant part used, preparation methods, wound categories treated, dosage, frequency, and contraindications known to traditional practitioners remain undocumented in any indexed publication.

No quantitative ethnobotanical survey has been conducted for *B. malcolmii*. Quantitative indices – Use Value (UV), Relative Frequency of Citation (RFC), Informant Consensus Factor (ICF), and Fidelity Level (FL%) – constitute the current standard for evidence-based ethnobotanical documentation and are required for publication in high-impact ethnobotanical journals.[25] Their complete absence for *B. malcolmii* prevents objective assessment of cultural salience, geographic scope of traditional use, and degree of practitioner consensus regarding therapeutic application.

Comparative Ethnobotany within the Genus

The wound healing ethnobotanical attribution of *B. malcolmii* acquires biological credibility when positioned within the broader ethnomedicinal landscape of the genus (Table 4). The convergence of wound healing indications across *B. malcolmii*, *B. lacera*, and *B. balsamifera* – phylogenetically related species within the same genus (*Blumea*

DC.) – provides preliminary ethnopharmacological support for this activity.

Table 4: Ethnobotanical comparison of Blumea malcolmii with selected congeners

Species	Local name	Traditional uses	Region	Ref.
B. malcolmii	Panjrut	Wound healing (cuts, infected wounds)	Maharashtra, Karnataka, India	15, 19
B. lacera	Kakronda; Kukkuradru	Anti-inflammatory, anthelmintic, antidiarrheal, antimicrobial, hepatoprotective, wound healing	India, China, tropical Africa	8, 26
B. balsamifera	Sambong; Ai na xiang	Kidney stones, sinusitis, diuretic, wound healing, antitumour	Southeast Asia, China	6, 7
B. eriantha	—	Larvicidal, anti-inflammatory	India	27, 28
B. mollis	—	Antimicrobial, anti-inflammatory	India	29

PHYTOCHEMISTRY

Essential Oil: Historical Characterization and Definitive GC-MS Reinvestigation

Simonsen and Rau (1922): First chemical investigation

The first phytochemical investigation of *B. malcolmii* essential oil was conducted by Simonsen and Rau (1922), published in the *Journal of the Chemical Society Transactions* (Vol. 121, pp. 876–883).[12] This study employed fractional distillation, chemical derivatization, and optical rotation measurements – in the complete absence of chromatographic separation technology. While it established the presence of terpenoid volatile constituents, its compositional data are not directly comparable to contemporary GC-MS analyses and must be considered of historical value only.

Joshi and Pai (2016): Definitive modern characterization

After nearly a century, Joshi and Pai (2016) conducted the first modern analytical characterization of *B. malcolmii* essential oil, published in *Natural Product Research*.[15] This represents the current definitive phytochemical characterization of the species' volatile fraction.

Joshi and Pai (2016) identified 18 compounds accounting for 99.2% of the total oil. Carvotanacetone was the dominant constituent at 92.1%, with its identity confirmed independently by both GC-MS spectral matching and NMR spectroscopy (^{1}H and ^{13}C), conferring high structural certainty. Carvomenthone (2.3%) and (E)-β-caryophyllene (1.1%) were the second and third most abundant constituents respectively. Oxygenated monoterpenes collectively constituted 95.0% of the total oil composition. Plant material was sourced from whole plants collected in the Western Ghats region (Belgaum, Karnataka).[15] This finding has been independently cited and confirmed in subsequent comparative *Blumea* essential oil studies. [30]

Carvotanacetone [systematic IUPAC name: (5R)-2-methyl-5-(propan-2-yl)cyclohex-2-en-1-one; CAS 499-71-8] is an oxygenated monoterpene ketone structurally related to carvone and pulegone, possessing an endocyclic C2=C3 double bond and a propan-2-yl substituent at C5. It occurs at varying concentrations in other *Blumea* species, including *B. eriantha* and variably *B. lacera*,[30] but never at concentrations approaching the 92.1%

dominance recorded in *B. malcolmii*. This near-monocomponent essential oil composition chemotypically distinguishes *B. malcolmii* from all characterized *Blumea* congeners and constitutes the most pharmacologically tractable feature of this species.

Table 5: Essential oil composition of B. malcolmii compared to selected Blumea congeners

Species	Major constituent(s)	%	Origin	Ref.
B. malcolmii	Carvotanacetone	92.1%	India (Western Ghats)	15
B. lacera	2,5-Dimethoxy-p-cymene; β-caryophyllene; carvotanacetone (chemotype-dependent)	Variable	India (multiple regions)	30
B. balsamifera	Borneol	33.2%	Bangladesh	31
B. lanceolaria	Phytol; caryophyllene oxide	Variable	India (Western Ghats)	32
B. eriantha	(4E,6Z)-Allo-ocimene; carvotanacetone; dodecyl acetate	~10.6%	India	27

Flavonoids: Isolation, Structural Correction, and Chemical Significance

Original isolation: Kulkarni et al. (1987)

Four novel 6-hydroxyflavonol aglycones were first isolated from *B. malcolmii* and reported by Kulkarni MM et al. (1987) in *Phytochemistry*.[13] The originally proposed structures, based on UV spectroscopy, mass spectrometry, NMR analysis, and chemical correlations, were identified as: 6-Hydroxy-3,5,7,4′-tetramethoxyflavone; 6,2′,5′-Trihydroxy-3,5,7-trimethoxyflavone; 6,5′-Dihydroxy-3,5,7,2′-tetramethoxyflavone; and 6-Hydroxy-3,5,7,2′,5′-pentamethoxyflavone.

Structural reassignment: Markham (1989)

Markham KR (1989) subjected the spectroscopic data of Kulkarni et al. (1987) to critical re-examination and demonstrated systematic misinterpretation of the spectral evidence, in a paper published in *Phytochemistry*.[14] The corrected structures were identified as methyl ethers of quercetagetin (3,5,6,7,3′,4′-hexahydroxyflavone): (1) 5,3′-dihydroxy-3,6,7,4′-tetramethoxyflavone; (2) 5,3′,4′-trihydroxy-3,6,7-trimethoxyflavone; (3) 5,4′-dihydroxy-3,6,7,3′-tetramethoxyflavone; (4) 5-hydroxy-3,6,7,3′,4′-pentamethoxyflavone.

Table 6: Flavonoid constituents of Blumea malcolmii — original and corrected structures

No.	Original structure (Kulkarni et al., 1987)[13]	Corrected structure (Markham, 1989)[14]
1	6-Hydroxy-3,5,7,4′-tetramethoxyflavone	5,3′-dihydroxy-3,6,7,4′-tetramethoxyflavone
2	6,2′,5′-Trihydroxy-3,5,7-trimethoxyflavone	5,3′,4′-trihydroxy-3,6,7-trimethoxyflavone
3	6,5′-Dihydroxy-3,5,7,2′-tetramethoxyflavone	5,4′-dihydroxy-3,6,7,3′-tetramethoxyflavone
4	6-Hydroxy-3,5,7,2′,5′-pentamethoxyflavone	5-hydroxy-3,6,7,3′,4′-pentamethoxyflavone

Chemical significance of the quercetagetin methyl ethers

Quercetagetin (3,5,6,7,3′,4′-hexahydroxyflavone) is a 6-hydroxyflavonol enriched in flowers of genus *Tagetes* and *Citrus* peel, and represents a chemotaxonomically significant flavonoid class within Asteraceae.[33,34,35] Its biosynthesis proceeds via the enzyme flavonol 6-hydroxylase, which catalyzes hydroxylation at C-6 of quercetin. [34]

Progressive methoxylation of quercetagetin to yield the four isolated ethers from *B. malcolmii* carries direct pharmacological significance. Replacement of hydroxyl groups with methoxy groups (i) increases lipophilicity and cellular

membrane permeability; (ii) reduces susceptibility to phase II glucuronidation and sulfation metabolism, thereby enhancing systemic bioavailability; and (iii) modifies receptor binding affinity relative to the parent polyhydroxylated compound.[36] The four quercetagetin methyl ethers of *B. malcolmii* are structurally unambiguous following Markham's (1989) correction.[14]

Crude Extract Phytochemical Profiling

The complete phytochemical evidence base for the species is consolidated in Table 7.

Table 7: Complete phytochemical evidence base for Blumea malcolmii (C.B.Clarke) Hook.f.

Constituent class	Specific compound(s)	Detection basis	Isolation status	Ref.
Volatile oil	Carvotanacetone (92.1%), carvomenthone (2.3%), (E)-β-caryophyllene (1.1%), 15 minor compounds	GC-FID, GC-MS, ^{1}H NMR, ^{13}C NMR	Characterized in situ	15
Flavonoid aglycones	4 quercetagetin methyl ethers (structurally corrected)	UV, MS, NMR spectroscopy	Isolated; confirmed	13, 14
Flavonoid glycosides	Not characterized	Qualitative colorimetric test	Not isolated	19
Saponin glycosides	Not characterized	Froth test	Not isolated	19
Alkaloids	Not characterized	Mayer's, Dragendorff's reagents	Not isolated	19
Tannins	Not characterized	Ferric chloride test	Not isolated	19

The qualitative phytochemical screening data of Suryawanshi et al. (2021)[19] represent an initial step in the pharmacognostic research hierarchy. No HPLC, LC-MS, NMR-based metabolomics, or bioassay-guided fractionation study has been reported for any crude extract of *B. malcolmii*. The complete absence of quantitative analytical data for the non-volatile fraction constitutes a major analytical gap.

BIOTECHNOLOGICAL APPLICATIONS: PHYTOREMEDIATION STUDIES

A distinct body of literature experimentally demonstrates biological activity of *B. malcolmii* cellular systems in biotechnological phytoremediation applications, constituting the only published experimental studies using this species' biological material under controlled laboratory conditions prior to the pharmacognostic study of Suryawanshi et al. (2021).[19]

Kagalkar et al. (2009)[16] established cell suspension cultures of *B. malcolmii* on Murashige and Skoog (MS) medium supplemented with coconut milk, 2,4-dichlorophenoxyacetic acid, glutamine, and sucrose, and demonstrated their capacity to decolorize the sulfonated azo dye Direct Red 5B. Enzymatic analysis revealed induction of lignin peroxidase, tyrosinase, 2,6-dichlorophenolindophenol (DCIP) reductase, azoreductase, and riboflavin reductase during degradation, confirming active enzymatic biotransformation. HPLC and FTIR analyses confirmed phytotransformation of the dye substrate rather than mere physical adsorption.

In a subsequent study, Kagalkar et al. (2011)[17] demonstrated that cell suspension cultures of *B. malcolmii* could rapidly decolorize a structurally diverse range of dyes; the most rapid decolorization was recorded for Malachite Green, a triphenylmethane dye, at 93.41% within 24 hours. Enzymatic analysis revealed induction of

laccase, veratryl alcohol oxidase, and DCIP reductase; HPLC and GC-MS analyses confirmed enzymatic degradation of the dye.

Adki et al. (2011)[18] extended this work by demonstrating that actively dividing *B. malcolmii* cell suspension cultures could successfully detoxify Troysan S-89, a carcinogenic paint preservative comprising carbendazim, diuron, and 2-octyl-2H-isothiazol-3-one. The robust enzymatic activity demonstrated in these studies confirms the metabolic competency of *B. malcolmii* cell cultures.

PHARMACOLOGICAL ACTIVITIES

Direct Therapeutic Pharmacological Evidence

No formal *in vitro* or *in vivo* therapeutic pharmacological study – antimicrobial, anti-inflammatory, antioxidant, wound healing, cytotoxic, analgesic, antifungal, anthelmintic, or any other – has been published for *Blumea malcolmii* (C.B.Clarke) Hook.f. as of May 2026. The phytoremediation cell culture studies demonstrate cellular metabolic activity but are not therapeutically relevant in a pharmacological context. The species' therapeutic pharmacological profile is entirely absent from the experimental literature despite over a century of phytochemical characterization and a well-documented wound healing ethnobotanical use.

Carvotanacetone: Known Bioactivities in Related Systems

Given that carvotanacetone constitutes 92.1% of *B. malcolmii* essential oil,[15] bioactivity data for this compound in other plant systems provide the most directly applicable evidence for predicting the volatile fraction's pharmacological properties. All activities below are documented for carvotanacetone as an isolated compound or major essential oil constituent in other species and are presented as testable hypotheses for *B. malcolmii*, not as established facts for this species.

1. **Larvicidal activity:** Benelli et al. (2017)[27] demonstrated that *B. eriantha* essential oil, in which carvotanacetone is a constituent at 10.6%, exhibited larvicidal LC50 values of 41.61–61.33 µg/ml against third-instar larvae of six mosquito species, including *Aedes aegypti* (Zika virus vector), *Anopheles stephensi* (malaria vector), and *Culex quinquefasciatus* (filariasis vector). Critically, pure isolated carvotanacetone achieved LC50 values below 10 µg/ml against all six species tested – substantially more potent than the whole oil. Given that *B. malcolmii* essential oil contains 92.1% carvotanacetone – nearly nine times the concentration found in *B. eriantha* – markedly potent larvicidal activity is predicted.

2. **Antimicrobial activity:** Oxygenated monoterpene ketones structurally analogous to carvotanacetone (carvone, pulegone, menthone) exhibit broad-spectrum antimicrobial activity against Gram-positive bacteria, Gram-negative bacteria, and fungi through membrane disruption mechanisms.[37]

3. **Antiproliferative activity:** Carvotanacetone derivatives from *Sphaeranthus ukambensis* (Asteraceae) demonstrated inhibition of the ubiquitin-proteasome pathway in human colon cancer cells, with potency in the micromolar range.[38]

4. **Anti-inflammatory and wound healing:** Monoterpene ketones related to carvotanacetone, including carvone, pulegone, and menthone, exhibit anti-inflammatory properties through inhibition of pro-inflammatory mediators.[37] This is

consistent with the ethnomedicinal wound healing uses documented for *Blumea* species.[8]

Quercetagetin Methyl Ethers: Predicted Molecular Targets

The four quercetagetin methyl ethers[13,14] are structurally defined polymethoxylated flavonols with predictable molecular pharmacology based on documented activities of the parent compound quercetagetin and structurally analogous polymethoxylated flavonoids:

1. **COX-1/COX-2 inhibition:** Quercetagetin possesses potent anti-inflammatory properties including COX inhibitory activity.[34] The increased lipophilicity of the four methyl ethers relative to parent quercetagetin is predicted to enhance membrane penetration and active-site binding. *In silico* molecular docking against the human COX-2 crystal structure (PDB: 5IKT, tolfenamic acid-bound, Orlando and Malkowski, 2016) is proposed as an feasible without delay, zero-cost first-tier study.

2. **iNOS inhibition:** Polymethoxylated flavonoids exhibit anti-inflammatory activity relevant to wound healing through inhibition of inducible nitric oxide synthase (iNOS) and modulation of proinflammatory gene expression.[39]

3. **Antioxidant mechanisms:** Quercetagetin is a potent radical scavenger owing to its catechol-type B-ring and additional C-6 hydroxyl group. Its methyl ethers retain partial radical-scavenging capacity with altered kinetics relative to the parent compound.[34]

4. **ADMET profile:** Computational ADMET prediction using pkCSM[40] and ProTox-II[41] for the four quercetagetin methyl ether structures and carvotanacetone is recommended as a low-cost preliminary pharmacokinetics and safety screen prior to experimental bioassay design.

Chemotaxonomically Extrapolated Pharmacological Activities

The activities in Table 8 are inferred from genus-level experimental evidence and are presented explicitly as testable hypotheses for *B. malcolmii*, not as established facts. Experimental validation is required before any of these activities may be attributed to *B. malcolmii*.

Table 8: Chemotaxonomically extrapolated pharmacological activities for Blumea malcolmii (hypothetical; require experimental validation)

Activity	Source species	Experimental evidence	Phytochemical basis	Ref.
Wound healing	*B. balsamifera, B. lacera*	Excision wound model; scratch assay; in vitro	Flavonoids, terpenoids, saponins	42, 43
Antimicrobial	*B. lacera, B. mollis, B. balsamifera*	Minimum inhibitory concentration (MIC) broth microdilution; disc diffusion	Essential oil, tannins, alkaloids	29, 44, 45
Anti-inflammatory	*B. lacera, B. balsamifera*	Carrageenan paw edema; COX inhibition	Flavonoids, terpenoids	6, 8
Antioxidant	*B. balsamifera, B. lacera*	2,2-diphenyl-1-picryl hydrazyl (DPPH) , 2,2′-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS), ferric reducing antioxidant power (FRAP)	Polyphenols, flavonoids, tannins	6, 45
Anthelmintic	*B. lacera*	*In vitro* (*Pheretima posthuma*)	Alkaloids, saponins	8, 46
Hepatoprotective	*B. balsamifera*	CCl_4-induced hepatotoxicity	Flavonoids (blumeatin)	47

Larvicidal	*B. eriantha*	LC_{50} against six mosquito species	Carvotanacetone	27
Plasmin inhibition	*B. balsamifera*	Plasmin inhibition assay	Flavonoids	48

TOXICOLOGY AND SAFETY PROFILE

No toxicological data of any category – acute, sub-acute, sub-chronic, chronic, genotoxic, reproductive, developmental, or dermal – have been published for *B. malcolmii*, its crude extracts, or its isolated constituents (carvotanacetone or the four quercetagetin methyl ethers) in any mammalian or non-mammalian model. No toxicological data exist for this species for an ethnobotanically active species with documented folkloric wound healing use.

OECD Test Guideline 423 (Acute Toxic Class Method)[49] and OECD Test Guideline 407 (Repeated Dose 28-Day Oral Toxicity Study in Rodents)[50] constitute the minimum required assessments before any preclinical pharmacological advancement can be justified. Computational *in silico* toxicity prediction using ProTox-II[41] and pkCSM[40] applied to the confirmed major constituents – carvotanacetone and the four quercetagetin methyl ethers – would provide zero-cost preliminary safety data to guide experimental design priorities. Based on analogous compounds in the oxygenated monoterpene ketone and polymethoxylated flavonol classes, severe acute toxicity is not anticipated; however, empirical species-specific toxicological data remain mandatory and cannot be substituted by inference from related compounds or genera.[51]

RESEARCH GAPS AND FUTURE PERSPECTIVES

The critical observation is that the highest-priority gaps require neither novel plant collection, de novo isolation, nor structural elucidation; only systematic bioassay of confirmed, structurally defined compounds (Table 9).

Table 9: Research gaps and prioritized future investigations for Blumea malcolmii (C.B.Clarke) Hook.f.

Domain	Identified gap	Priority	Recommended approach
Therapeutic pharmacology	No *in vitro* or *in vivo* studies published	Critical	Wound healing scratch assay; antimicrobial MIC; DPPH/ABTS antioxidant assays
***In vivo* validation**	No animal model studies	Critical	Excision wound model (rat, CPCSEA [Committee for the Purpose of Control and Supervision of Experiments on Animals]-approved); carrageenan paw edema model
Toxicology	No safety data of any category	Critical	OECD TG 423 acute oral; OECD TG 407 sub-acute 28-day; ProTox-II *in silico*
Carvotanacetone bioassay	Confirmed at 92.1%; pharmacologically unevaluated for this species	High	Larvicidal LC_{50}; antimicrobial MIC; anti-inflammatory; wound healing assays
Quercetagetin methyl ether bioassay	Structurally defined >35 years; never bioassayed	High	COX-2 inhibition; DPPH/ABTS; cytotoxicity 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay
***In silico* pharmacology**	No molecular docking or ADMET data available	High	AutoDock Vina docking vs. COX-2 (PDB: 5IKT), iNOS, vascular endothelial growth factor receptor-2 (VEGFR-2); pkCSM, SwissADME
Non-volatile phytochemistry	No LC-MS, HPLC, or NMR metabolomics data	High	UHPLC-QTOF-MS [Ultra-High Performance Liquid Chromatography–

			Quadrupole Time-of-Flight Mass Spectrometry] metabolomics; bioassay-guided fractionation
Ethnobotany (quantitative)	No UV, RFC, ICF, or FL% indices determined	High	Field survey (Maharashtra, Karnataka); standardized quantitative indices
Multi-organ phytochemistry	Only leaf and whole plant essential oils characterized	Medium	Comparative profiling of stem, root, flower, seed material
DNA barcoding	No molecular authentication data	Medium	ITS2, rbcL, matK barcoding; authentication standard development
Population ecology	Distribution known; no population census	Medium	Field-based population survey; demographic assessment
Conservation assessment	No IUCN Red List evaluation	Medium	Threat assessment against IUCN criteria A–E

The single highest-impact, lowest-resource-cost investigation immediately actionable is *in silico* molecular docking and ADMET prediction of carvotanacetone and the four quercetagetin methyl ethers against wound-healing molecular targets (COX-2, iNOS, VEGFR-2). All structural data are publicly available and confirmed; calculations require only free widely-used docking platforms (AutoDock Vina) and publicly accessible crystal structures (RCSB PDB). This constitutes an independently publishable computational study and generates experimentally testable hypotheses without reagent expenditure.

The second priority is *in vitro* bioassays of the essential oil and commercially available pure carvotanacetone against wound-healing targets (scratch assay, excision wound model), common wound pathogens (*Staphylococcus aureus*, *Pseudomonas aeruginosa*), and a mosquito larval bioassay to empirically validate the genus-level carvotanacetone larvicidal prediction. These studies can proceed without requiring plant extraction or de novo isolation.

CONCLUSION

Blumea malcolmii (C.B.Clarke) Hook.f. is a species whose scientific profile is characterised by a striking contrast: it is nomenclaturally well-resolved with five recorded synonyms, geographically documented across five Indian states, morphologically characterized, ethnobotanically active in wound healing, and possesses confirmed phytoconstituents including a near-monocomponent essential oil dominated by carvotanacetone at 92.1% and four structurally defined quercetagetin methyl ethers; yet its therapeutic pharmacological profile remains entirely unexplored in the experimental literature.

This review, the first of its kind for *B. malcolmii*, consolidates the complete species-specific literature from 1876 to 2026 through a methodologically complete synonym-based bibliometric search. It corrects historical errors present in the prior literature, including the omission of Kulkarni et al. (1987)[13] as the original flavonol isolation paper, supplements the distribution record to include Karnataka, Kerala, Tamil Nadu, and Madhya Pradesh, and underscores the structural correction of Markham (1989)[14] as the definitive flavonoid dataset for the species. Enzymatic oxidoreductase activity demonstrated in phytoremediation cell culture studies[16,17,18] confirms the species' metabolic competency.

The path from the existing evidence base to publishable pharmacological data is shorter for *B.*

malcolmii than for most under-investigated medicinal plants. It requires neither novel isolation nor structural elucidation – only systematic bioassay of confirmed, structurally defined, commercially accessible compounds.

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