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Curcuma inodora Blatt.: Sesquiterpene-Dominant Phytochemistry and Comparative Chemotaxonomic Evaluation within the Genus Curcuma: A Review

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Abstract: *Curcuma inodora Blatt. (Zingiberaceae), a peninsular Indian endemic, stands out as one of the least explored Curcuma species despite folk uses for inflammation, pain, and digestion. This review consolidates its sesquiterpene-dominant phytochemistry: leaf oils feature caryophyllene (~31%), benzofuran derivatives (~21%), γ-elemene, phytol, and minor α-bisabolol; rhizome oils from Konkan show α-bisabolol as the standout major (up to 62.13%), with β-bisabolene and β-thujene, firmly anchoring it in the essential oil-rich chemotype, distinct from curcuminoid-heavy species like C. longa. Non-volatiles (phenolics, flavonoids, diarylheptanoids, curcuminoids) remain undetected, though genus biosynthetic conservation implies potential presence. Recent in vitro, in silico, and toxicity data reveal robust antimicrobial, antioxidant (DPPH/NO scavenging), and anti-inflammatory effects, largely driven by α-bisabolol, plus excellent safety (LD_{50} > 2000 mg/kg) and favourable ADME. These results validate traditional applications and signal strong therapeutic promise. Yet major gaps persist: non-volatile profiling (LC–MS/HRMS/NMR), population metabolomic variability, and full pharmacological validation. Urgent multidisciplinary work is needed to map unique markers, refine chemotaxonomic placement, and unlock C. inodora's potential in natural products and herbal medicine.*

Keywords: *Curcuma inodora*, Genus Curcuma, Zingiberaceae, Sesquiterpenes, Phytochemical profiling

1. Introduction

Medicinal plants remain one of the most important sources of structurally diverse bioactive molecules and continue to play a vital role in modern drug discovery, traditional healthcare, and nutraceutical research. A substantial proportion of approved therapeutic agents originate directly or indirectly from natural products, highlighting the continued relevance of phytochemical investigations [1,2]. Among medicinal plant families, Zingiberaceae occupies a prominent position due to its aromatic rhizomatous members and a wide spectrum of secondary metabolites. Plants belonging to this family are widely used in food, cosmetics, and medicine, and their pharmacological properties are mainly attributed to terpenoids, diarylheptanoids, phenolics, and flavonoids that exhibit antioxidant, anti-inflammatory, antimicrobial, hepatoprotective, and anticancer activities [3,4].

Within this family, the genus *Curcuma* is one of the most taxonomically complex and pharmacologically significant groups, comprising more than 100 species distributed mainly in tropical Asia. India is considered one of the primary centres of diversity for this genus, with several species integral to Ayurvedic and folk medicine [5]. Well-known members such as turmeric (*Curcuma longa*), zedoary (*Curcuma zedoaria*), and wild turmeric (*Curcuma aromatica*) have been extensively studied for their chemical composition and therapeutic potential. These species are particularly valued for their essential oils rich in mono- and sesquiterpenes, along with diarylheptanoids such as curcuminoids that contribute to their biological activities [6–8].

Phytochemically, *Curcuma* species are characterized by three major classes of metabolites: volatile terpenoid-rich essential oils, curcuminoid-type diarylheptanoids, and diverse phenolic and flavonoid constituents. These metabolites are produced through conserved biosynthetic pathways and often vary among species due to ecological adaptation, genetic variability, and environmental factors [4,9]. Such variation makes phytochemical profiling an important tool not only for identifying pharmacologically valuable compounds but also for understanding evolutionary relationships within the genus. While commercially important species have received substantial scientific attention, many endemic or regionally distributed taxa remain insufficiently explored.

One such under-studied species is *Curcuma inodora* Blatt., a rhizomatous herb endemic to peninsular India and found in lateritic plateaus, open forest habitats, and monsoon-dependent ecosystems. Ethnobotanical reports indicate its traditional use in the management of inflammation, muscular pain, digestive disturbances, and certain stress-related disorders, suggesting the presence of bioactive secondary metabolites [10]. Despite these traditional claims, only limited phytochemical investigations have been carried out, with most available information restricted to preliminary essential oil analysis. Interestingly, although the species is described as relatively non-aromatic compared to turmeric, analytical studies have confirmed the presence of sesquiterpenes, oxygenated terpenoids, and other volatile compounds [11].

Given the chemical richness of the genus and the medicinal relevance of endemic species, a consolidated review of the phytochemical profile of *Curcuma inodora* is both timely and necessary. The present article, therefore, aims to compile available chemical data on the species, analyse its known metabolite composition, and compare it with other well-studied *Curcuma* taxa to identify chemotaxonomic patterns and research gaps. By integrating existing literature with genus-level phytochemical insights, this review seeks to provide a scientific foundation for future studies on metabolomics, bioactivity-guided isolation, and pharmacological evaluation of this promising but insufficiently explored medicinal plant.

2. Botanical Overview and Distribution

Curcuma inodora Blatt. is a perennial rhizomatous herb belonging to the family Zingiberaceae, a group characterized by aromatic species with underground storage organs rich in essential oils and secondary metabolites. Morphologically, the species shares several diagnostic features with other members of the genus *Curcuma*, including stout fleshy rhizomes, pseudostems formed by overlapping leaf sheaths, and broad lanceolate leaves arranged in two rows. The inflorescence typically emerges from the rhizome and bears pale yellow to creamy-white flowers enclosed within green bracts. In contrast to well-known species such as turmeric, the rhizomes of *C. inodora* possess only a faint aroma, which is reflected in its specific epithet. The plant follows a seasonal growth pattern common to tropical geophytes, showing vigorous vegetative growth during the monsoon and entering dormancy during the dry season [12,13].

The species is considered endemic to peninsular India and has been documented primarily from lateritic plateaus, moist deciduous forests, and open scrub habitats of Maharashtra, Karnataka, and neighbouring regions. It prefers well-drained, iron-rich soils and is often found in monsoon-dependent herbaceous communities that emerge after seasonal rainfall. Floristic surveys indicate that *C. inodora* occurs in scattered, localised populations rather than in continuous distributional ranges, suggesting ecological specificity and possible sensitivity to habitat alteration [14,15]. Such restricted distribution is typical of several endemic *Curcuma* taxa and is of particular interest from both conservation and phytochemical perspectives, since geographically confined species often develop distinct metabolite profiles shaped by localized environmental pressures and evolutionary adaptation [16].


Fig. 1. ***C.inodora*** **species in its natural habitat and its inflorescence**

3. Phytochemical Investigations of *C. inodora*

3.1 Essential Oil Composition

The first detailed phytochemical study of *C. inodora* was carried out through gas chromatography–mass spectrometry (GC–MS) analysis of its leaf essential oil, which revealed a complex mixture of volatile metabolites dominated by sesquiterpenoid compounds. The presence of such terpenoid-rich fractions is consistent with the chemical pattern observed in several species of the genus, where essential oils constitute an important component of the plant's defensive and pharmacologically active metabolites [17]. Quantitative analysis demonstrated that caryophyllene-type sesquiterpenes form the principal fraction of the oil. In addition, benzofuran derivatives and substituted cyclohexane compounds were detected in significant proportions. Other constituents such as γ-elemene, α-caryophyllene, β-pinene, phytol, and α-bisabolol were present in smaller amounts, indicating a chemically diverse volatile profile. The major constituents reported from the leaf oil are summarized in Table 1.

Table 1. Major constituents of *C. inodora* leaf essential oil

Compounds	Approximate percentage
Caryophyllene	**~31%**
Benzofuran derivatives	~21%
Cyclohexane derivatives	~11%
α-Caryophyllene	~6%
γ-Elemene	~5%
β-Pinene	~4%
Phytol	~3%
α-Bisabolol	~2%

The predominance of caryophyllene-type sesquiterpenes in *C. inodora* is consistent with essential oil compositions reported for several medicinal *Curcuma* species, where such compounds frequently represent major bioactive components. Caryophyllene and its derivatives have been widely associated with anti-inflammatory, antimicrobial,

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antioxidant, and cytoprotective properties, while compounds such as bisabolol and elemene derivatives are known for their therapeutic relevance in antimicrobial and anticancer research. The occurrence of these metabolites therefore provides a plausible phytochemical basis for some of the ethnomedicinal uses attributed to the plant and highlights the pharmacological potential of its volatile fraction [17].

3.2 Terpenoid and Sesquiterpenoid Chemistry

Terpenoids constitute the dominant class of secondary metabolites reported in *C. inodora*, particularly within its volatile fraction [11] as depicted in Table 2. Current evidence indicates that the species synthesizes a range of sesquiterpene hydrocarbons, oxygenated sesquiterpenes, and smaller quantities of monoterpenes. Such a profile is consistent with the general metabolic pattern of the genus *Curcuma*, in which terpenoid-rich essential oils form a major chemotaxonomic feature and contribute significantly to biological activity. The presence of compounds such as caryophyllene derivatives, bisabolol analogues, and elemene-type molecules suggests that the plant shares biosynthetic pathways common to other medicinally important members of the genus [18,19].

Table 2. Major constituents of *C. inodora* rhizome essential oil

Sr. No.	Components	Approximate (%)
1.	β - Thujene	4.23
2.	4-Terpinol	2.99
3.	Oxiranemethanol,3-methyl-3-(4-methyl-3-pentyl)	3.37
4.	Cyclopropanemethanol, α,2-dimethyl-2-[(4-methyl-3-pentenyl)-[1α(R*)2α]	7.45
5.	β -Farnesene	3.09
6.	D-nerolidol	1.15
7.	Trans-Z-α-Bisabolene epoxide	1.02
8.	6,11-Dimethyl -2,6,10-dodecatrien-1-ol	1.72
9.	**Bisabolol oxide-II**	**7.63**
10.	**α - Bisabolol**	**66.13**
11.	Retinal	1.14

In related *Curcuma* species, terpenoid constituents are known to play a key pharmacological role. Turmerones from *Curcuma longa* and curzerenone-type sesquiterpenes from *Curcuma zedoaria* have demonstrated anti-inflammatory, antioxidant, and cytotoxic activities, indicating the therapeutic relevance of these metabolite groups. Particularly noteworthy is the occurrence of elemene derivatives in *C. inodora*, since β-elemene has been widely investigated for its anticancer potential, including tumor growth inhibition and apoptosis induction. The detection of such compounds supports the medicinal significance of the species and highlights the need for further phytochemical and bioactivity-guided studies to fully explore its pharmacological potential [9,17, 20,21, 22, 23].

3.3 Phenolics, Curcuminoids, and Diarylheptanoids (Probable Constituents)

To date, the direct isolation of curcuminoids or related diarylheptanoids from *C. inodora* has not been conclusively documented. Nevertheless, comparative phytochemical studies across the genus *Curcuma* indicate that many species consistently accumulate phenolic metabolites such as curcumin analogues, demethoxycurcumin derivatives, diarylheptanoid-type compounds, as well as associated flavonoids and tannins. These compounds arise from conserved

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phenylpropanoid and polyketide biosynthetic pathways that are widely distributed among rhizomatous members of the Zingiberaceae, suggesting that similar metabolite classes may also be present in *C. inodora* [24,25].

Evidence from closely related taxa further supports this possibility. Species such as *Curcuma aromatica* and other medicinal members of the genus have been reported to contain both volatile terpenoids and non-volatile phenolic constituents, including curcuminoid-type molecules and structurally related diarylheptanoids. Given this strong biosynthetic conservation within the genus, it is reasonable to hypothesize that *C. inodora* may also synthesize comparable compounds. However, confirmation of these metabolites will require targeted chromatographic isolation, LC–MS profiling, and spectroscopic characterization to establish its non-volatile phytochemical composition with certainty [26, 27].

3.4 Other Secondary Metabolites

Preliminary phytochemical screening and genus-level comparisons indicate that *C. inodora* may contain additional minor secondary metabolites such as flavonoids, tannins, steroidal compounds, long-chain hydrocarbons, and diterpene alcohols, including phytol. Although these constituents have not yet been conclusively isolated from this species, their widespread occurrence in other Curcuma species suggests a similar metabolic pattern. Such compounds are commonly associated with antioxidant, anti-inflammatory, and protective biological roles, implying that they may contribute to the overall pharmacological potential of *C. inodora*. However, targeted chromatographic and spectroscopic investigations are still required to verify their presence and determine their quantitative significance [28].

4. Comparative Phytochemistry Across the Genus *Curcuma*

Comparative phytochemical assessment across the genus *Curcuma* indicates that while well-studied species such as *C. longa*, *C. zedoaria*, and *C. aromatica* contain diverse secondary metabolites including curcuminoids, sesquiterpenes, phenolics, and flavonoids that define their medicinal and aromatic value, the chemistry of *C. inodora* remains less explored. Available evidence suggests that it is primarily characterized by sesquiterpene-rich essential oils, making it chemically closer to aromatic species than to curcuminoid-dominant taxa. Overall, the genus shows clear chemotaxonomic diversity, with species-specific metabolite signatures, and current data place *C. inodora* within the sesquiterpene-dominant group, though further studies are needed to confirm the presence of curcuminoids or related diarylheptanoids in minor quantities.

Table 2. Major phytochemical classes reported in selected *Curcuma* species

Species	**Major phytochemicals**	**Key references**
Curcuma longa	Curcumin, demethoxycurcumin, turmerones, zingiberene, flavonoids	29
Curcuma zedoaria	Curzerenone, germacrone, curdione, furanodiene-type sesquiterpenes	30
Curcuma aromatica	Curcumene, xanthorrhizol, essential oils, terpenoids	31
Curcuma amada	Mangiferin, phenolics, essential oils, terpenes	32
Curcuma caesia	Camphor, ar-turmerone, cineole, sesquiterpenes	33
Curcuma inodora	α-Bisabolol, β-Bisabolene, Caryophyllene, benzofuran derivatives, phytol, elemene-type sesquiterpenes	11,17,18

Table 3. Comparative secondary metabolite distribution

Metabolite class	**Presence in genus**	**Evidence in *C. inodora***
Sesquiterpenes	Very common	Confirmed

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Monoterpenes	Common	Minor presence
Curcuminoids	Widespread	Not yet confirmed
Phenolics	Common	Expected
Flavonoids	Common	Probable
Steroids	Occasional	Possible

5. Chemotaxonomic Significance

Phytochemical profiles frequently provide important insights into evolutionary relationships within plant genera, and the genus Curcuma is well known for exhibiting chemically distinct lineages based on secondary metabolite dominance. Species rich in curcuminoids, such as *Curcuma longa*, differ markedly from those characterized by abundant essential oils and sesquiterpenes. The available phytochemical data for *C. inodora*, particularly the predominance of sesquiterpene constituents in its essential oil, support its placement within the essential-oil-rich chemotype of the genus. Such patterns are consistent with earlier chemotaxonomic studies showing that terpenoid composition often correlates with phylogenetic clustering in Zingiberaceae plants [34, 35].

Interestingly, despite active terpenoid biosynthesis, *C. inodora* lacks the strong rhizome aroma typical of many aromatic *Curcuma* species. This feature may be explained by relatively low essential-oil accumulation in underground parts, preferential synthesis of volatiles in aerial tissues such as leaves, or ecological and environmental influences on secondary metabolism. Similar metabolic plasticity has been reported in other *Curcuma* taxa where geography, climate, and developmental stage influence oil composition and yield. Comprehensive metabolomic and population-level phytochemical studies are therefore needed to determine whether *C. inodora* represents a chemically intermediate lineage within the genus or a distinct sesquiterpene-specialized species [36].

6. Pharmacological Potential of *Curcuma inodora*

Although pharmacological investigations of *C. inodora* have been limited until recently, emerging studies on its essential oil provide direct evidence of promising biological activities. A key investigation by Nagore et al. on rhizome essential oil from the Konkan region (a biodiversity hotspot) revealed a bisabolol-rich profile, with α-bisabolol as the dominant constituent (62.13% in hydrodistilled extract; 45.64% in ultrasound-assisted solvent extract), alongside β-bisabolene, β-thujene, and other sesquiterpenes. This composition supports potential anti-inflammatory, antimicrobial, antioxidant, and related effects, as demonstrated through comprehensive *in-vitro*, *in-silico*, and *in-vivo* evaluations [11,37].

The oil exhibited potent antibacterial activity against tested strains, strong antifungal effects (particularly against *Candida albicans*), significant antioxidant potential (notably in nitric oxide scavenging, alongside DPPH), and notable anti-inflammatory properties (via protein inhibition assays). These findings align with the known bioactivities of sesquiterpenes like α-bisabolol, which interacts with inflammatory pathways, and bisabolene derivatives, contributing to gastroprotective, analgesic, immunomodulatory, and cytoprotective roles. Molecular docking confirmed strong binding affinities of α-bisabolol to relevant target proteins (e.g., binding energies of -7.01 to -8.15 kcal/mol for anti-bacterial, anti-fungal, anti-oxidant, and anti-inflammatory targets), while SwissADME profiling indicated favorable pharmacokinetics (high GI absorption, no Lipinski violations, good bioavailability). Acute oral toxicity studies in Wistar rats showed LD_{50} > 2000 mg/kg with no adverse histopathological effects, confirming safety.

Sesquiterpenes such as β-caryophyllene are known to interact with inflammatory signalling pathways and exhibit gastroprotective, analgesic, and immunomodulatory activities. Likewise, elemene-type compounds have attracted attention for their reported anticancer and cytotoxic effects in several medicinal plants. If present in sufficient concentrations, these molecules could contribute significantly to the pharmacological potential of *C. inodora*. However, direct bioactivity studies using extracts or isolated constituents from this species are still lacking, and systematic pharmacological evaluation is required to validate its medicinal relevance [38].

In addition to terpenoids, the probable occurrence of phenolics, flavonoids, and minor diterpenes may enhance its antioxidant and protective properties through synergistic mechanisms. Many *Curcuma* species show multi-target pharmacological effects due to the combined action of volatile oils and non-volatile phenolic compounds. Therefore, integrated phytochemical–pharmacological studies will be essential to determine whether *C. inodora* can be considered a medicinally valuable species or primarily a chemotaxonomic interest plant [39].

7. Research Gaps and Future Perspectives

Despite the botanical recognition of *C. inodora*, its phytochemistry remains insufficiently explored compared with other members of the genus. Existing studies are largely restricted to essential-oil profiling, with very limited data on non-volatile constituents such as curcuminoids, diarylheptanoids, flavonoids, or glycosides. Comprehensive chromatographic investigations using LC–MS, HRMS, and NMR-guided isolation are therefore needed to establish its complete metabolite spectrum. Such work would help determine whether the species possesses unique marker compounds or shares conserved biosynthetic pathways with other *Curcuma* taxa [11].

Another major research gap concerns pharmacological validation. To date, few systematic *in vitro* or *in vivo* studies appear to have evaluated antioxidant, anti-inflammatory, antimicrobial, or cytotoxic activity of *C. inodora* extracts. Considering the bioactive terpenoid profile suggested by essential-oil studies, screening against inflammation-related enzymes, microbial pathogens, and cancer cell lines would be particularly valuable. Integrating phytochemical profiling with bioassay-guided fractionation could reveal novel therapeutic leads and establish its medicinal significance [37].

Future research should also address ecological and metabolic variability. Comparative metabolomic studies across geographical populations, developmental stages, and plant parts may clarify whether the species shows chemical polymorphism similar to that reported in other *Curcuma* plants. Such information would be crucial for chemotaxonomy, conservation strategies, and potential cultivation. Overall, *C. inodora* represents a promising but underexplored member of the genus, and systematic multidisciplinary investigation could significantly enhance its scientific and medicinal relevance [40].

8. Conclusion

This review consolidates the current understanding of Curcuma inodora Blatt., an under-investigated Curcuma species defined by its sesquiterpene-dominant essential oils, particularly high α-bisabolol content in rhizome extracts, placing it firmly within the essential oil-rich chemotype, distinct from curcuminoid-dominant taxa such as *C. longa*. While non-volatile constituents, detailed pharmacological profiles, and metabolomic variability remain largely unexplored, emerging bioactivity data suggest promising medicinal relevance. Comprehensive phytochemical isolation, population-level metabolomics, and systematic bioactivity evaluation are now essential. Overall, *C. inodora* represents a promising yet underexplored taxon whose rigorous investigation could significantly advance chemotaxonomy, natural product discovery, and therapeutic applications.

REFERENCES

[1]. Newman DJ, Cragg GM (2016) Natural products as sources of new drugs. *J Nat Prod* 79:629–661.

[2]. Atanasov AG et al. (2021) Natural products in drug discovery: advances and opportunities. *Nat Rev Drug Discov* 20:200–216.

[3]. Poojita, P. & Nandha, A. (2025). Medicinal rhizomatous plants of the Zingiberaceae family: A review. *J. Pharm. and Phytochem.* 14(3):396-404

[4]. Amalraj A, Pius A, Gopi S, Gopi S (2017) Biological activities of *Curcuma* species. *J Tradit Complement Med* 7:205–233.

[5]. Ravindran PN, Nirmal Babu K, Sivaraman K (2007) *Turmeric: The Genus Curcuma*. CRC Press, Boca Raton.

[6]. Prasad S, Gupta SC, Aggarwal BB (2014) Turmeric, the golden spice: from traditional medicine to modern medicine. In: *Herbal Medicine: Biomolecular and Clinical Aspects*. CRC Press.

[7]. Akbar, S. (2020). *Curcuma zedoaria* (Christm.) Roscoe. (Zingiberaceae). In: Handbook of 200 Medicinal Plants. Springer, Cham.

[8]. Li S, Yuan W, Deng G, Wang P, Yang P, Aggarwal BB. (2011). Chemical composition and product quality control of turmeric. *Pharm Crops* 2:28–54.

[9]. Dosoky, N. S., & Setzer, W. N. (2018). Chemical composition and biological activities of essential oils of Curcuma species. *Nutrients*, *10*(9), 1196.

[10]. Aggarwal, G., Sharma, M., Singh, R., & Sharma, U. (2024). Ethnopharmacologically important highly subsidized Indian medicinal plants: Systematic review on their traditional uses, phytochemistry, pharmacology, quality control, conservation status and future prospective. *Journal of Ethnopharmacology*, *320*, 117385.

[11]. Nagore, P., Lokhande, P., & Mujawar, H. (2023). In-vitro bioevaluation, pharmacokinetics and molecular docking study of unexplored bisabolol-rich Curcuma inodora Blatt. essential oil from Konkan region: a biodiversity hotspot. Plant Sci Tod.,10(1): 223–231.

[12]. Kumar, K. M. P., Asish, G. R., Sabu, M., & Balachandran, I. (2013). Significance of gingers (Zingiberaceae) in Indian system of medicine-Ayurveda: An overview. *Ancient science of life*, *32*(4), 253-261.

[13]. Ravindran PN, Nirmal Babu K, Sivaraman K. (2007). *Turmeric: The Genus Curcuma*. CRC Press, Boca Raton.

[14]. Singh, N. P., Karthikeyan, S., Lakshminarasimhan, P., & Prasanna, P. V. (2000). Flora of Maharashtra State-Dicotyledons-Vol. 2. *Bot. Surv. India, Calcutta, India*.

[15]. Almeida MR (1996) *Flora of Maharashtra*, Vol. 6. Orient Press, Mumbai.

[16]. Sasikumar, B. (2005). Genetic resources of Curcuma: diversity, characterization and utilization. *Plant Genetic Resources*, *3*(2), 230-251.

[17]. Kumar, R., & Akkara, Y. (2017). Analysis by gas chromatography-mass spectrometry of the essential oil of *Curcuma inodora* Blatt. (Zingiberaceae) from Southern India. *Journal of Pharmacognosy and Phytochemistry*, *6*(4), 1629-1634.

[18]. Malek, S. N., Seng, C. K., Zakaria, Z., Ali, N. A., Ibrahim, H., & Jalil, M. N. (2006). The essential oil of Curcuma inodora aff. Blatter from Malaysia. *Journal of Essential Oil Research*, *18*(3), 281-283.

[19]. Santhoshkumar R, et al. (2019). Chemotaxonomic studies on rhizome extract compositions of twenty Curcuma species from South India. *Biochemical Systematics and Ecology,* 82:103-111.

[20]. Afzal, A., Oriqat, G., Akram Khan, M., Jose, J., & Afzal, M. (2013). Chemistry and biochemistry of terpenoids from Curcuma and related species. *Journal of Biologically Active Products from Nature*, *3*(1), 1-55.

[21]. Zhang, Y., Peng, F., & Yu, C. (2023). Therapeutic potential of Curcuma oil and its terpenoids in gynecological cancers. *Biomedicine & Pharmacotherapy*, *157*, 114016.

[22]. Rahaman, M. M., Rakib, A., Mitra, S., Tareq, A. M., Emran, T. B., Shahid-Ud-Daula, A. F. M., ... & Simal-Gandara, J. (2020). The genus curcuma and inflammation: overview of the pharmacological perspectives. *Plants*, *10*(1), 63.

[23]. Joshi, D. D., Deb, L., Somkuwar, B. G., Rana, V. S., Pant, M. K., Singh, B. K., & Uniyal, R. C. (2025). Opportunities and perspectives for molecular composition-based utilization of edible rhizomes of the genus Curcuma L. *South African Journal of Botany*, *187*, 68-79.

[24]. Alolga, R. N., Wang, F., Zhang, X., Li, J., Tran, L. S. P., & Yin, X. (2022). Bioactive compounds from the Zingiberaceae Family with known antioxidant activities for possible therapeutic uses. *Antioxidants*, *11*(7), 1281.

[25]. Kita, T., Imai, S., Sawada, H., Kumagai, H., & Seto, H. (2008). The biosynthetic pathway of curcuminoid in turmeric (Curcuma longa) as revealed by 13C-labeled precursors. *Bioscience, Biotechnology, and Biochemistry*, *72*(7), 1789-1798.

[26]. Kulyal, P., Acharya, S., Ankari, A. B., Kokkiripati, P. K., Tetali, S. D., & Raghavendra, A. S. (2021). Variable secondary metabolite profiles across cultivars of Curcuma longa L. and *C. aromatica* Salisb. *Frontiers in Pharmacology*, *12*, 659546.

[27]. Pintatum, A., Maneerat, W., Logie, E., Tuenter, E., Sakavitsi, M. E., Pieters, L., & Laphookhieo, S. (2020). In vitro anti-inflammatory, anti-oxidant, and cytotoxic activities of four Curcuma species and the isolation of compounds from Curcuma aromatica rhizome. *Biomolecules*, *10*(5), 799.

[28]. Yurasbe, N. Q., Din, N. A., Palaniveloo, K., Manikam, S., & Nagappan, T. (2023). Phytochemical diversity and biological activities of Curcuma species from the East Coast of Peninsular Malaysia. *Biodiversitas: Journal of Biological Diversity*, *24*(8).

[29]. Ahmad, R. S., Hussain, M. B., Sultan, M. T., Arshad, M. S., Waheed, M., Shariati, M. A., & Hashempur, M. H. (2020). Biochemistry, safety, pharmacological activities, and clinical applications of turmeric: a mechanistic review. *Evidence-Based Complementary and Alternative Medicine*, *2020*(1), 7656919.

[30]. Lobo, R., Prabhu, K. S., Shirwaikar, A., & Shirwaikar, A. (2009). *Curcuma zedoaria* Rosc.(white turmeric): a review of its chemical, pharmacological and ethnomedicinal properties. *Journal of Pharmacy and Pharmacology*, *61*(1), 13-21.

[31]. Xiang, H., Zhang, L., Yang, Z., Chen, F., Zheng, X., & Liu, X. (2017). Chemical compositions, antioxidative, antimicrobial, anti-inflammatory and antitumor activities of *Curcuma aromatica* Salisb. essential oils. *Industrial Crops and Products*, *108*, 6-16.

[32]. Policegoudra RS, Aradhya SM, Singh L. Mango ginger (*Curcuma amada* Roxb.) – A promising spice for phytochemicals and biological activities. Journal of Biosciences. 2011;36(5):739-748.

[33]. Anjum, A., & Chandra, V. (2026). A Comprehensive Review on the Broad-Spectrum Utility and Phytochemistry of Curcuma caesia Roxb. *Phytomedicine Plus*, 100961.

[34]. Záveská, E., Fér, T., Šída, O., Krak, K., Marhold, K., & Leong-Škorničková, J. (2012). Phylogeny of Curcuma (Zingiberaceae) based on plastid and nuclear sequences: Proposal of the new subgenus Ecomata. *Taxon*, *61*(4), 747-763.

[35]. Rattanakrajang, P., Tansawat, R., Wongsuwan, P., Nopporncharoenkul, N., Sirikantaramas, S., & Sukrong, S. (2025). Integrative geno-metabolomics of tenasserim turmeric (*Curcuma candida* (Wall.) Techapr. & Škorničk.) with insights into volatile biosynthesis across the turmeric genus. *Computational and Structural Biotechnology Journal*, 25:4682-4698.

[36]. Sandeep, I. S., Sanghamitra, N., & Sujata, M. (2015). Differential effect of soil and environment on metabolic expression of turmeric (Curcuma longa cv. Roma). *Indian J Exp Biol*, *53*(6), 406-11.

[37]. Nagore P., et al. (2025). Bioefficacy of α-Bisabolol-rich essential oil separated from Curcuma inodora rhizome of Konkan region, India. Plant Sci. Tod., 12:1-10.

[38]. Scandiffio, R., Geddo, F., Cottone, E., Querio, G., Antoniotti, S., Gallo, M. P., ... & Bovolin, P. (2020). Protective effects of (E)-β-caryophyllene (BCP) in chronic inflammation. *Nutrients*, *12*(11), 3273.

[39]. Dosoky, N. S., Satyal, P., & Setzer, W. N. (2019). Variations in the volatile compositions of Curcuma species. *Foods*, *8*(2), 53.

[40]. Chen, M., Sun, J., Yao, H., Gong, F., Cai, L., Wang, C., & Wang, Z. (2023). Analysis of genetic and chemical variability of five Curcuma species based on DNA barcoding and HPLC fingerprints. *Frontiers in Plant Science*, *14*, 1229041