Pharmacological properties of *Curcuma aromatica* Salisb and scope for its cultivation in Northeastern region of India

Abstract

Curcuma aromatica Salisb., also known as wild turmeric, is a perennial herb native to South and Southeast Asia, particularly India. It is renowned for its rhizomatous growth, distinct camphoraceousodor, and light yellow-orange rhizomes. The plant has a long-standing history in traditional medicine, especially in Ayurveda, where it has been used for over 6,000 years to treat various ailments, including skin diseases, digestive issues and infections. Rich in bioactive compounds such as curcumin, essential oils, terpenoids and flavonoids, *C. aromatica* exhibits significant pharmacological properties, including anti-inflammatory, antibacterial and anticancer effects. Beyond medicinal uses, it is valued in the cosmetic and food industries for its aromatic and antioxidant properties. In Northeast India, the plant holds cultural significance among local tribes, who utilize it for various health conditions. The rising demand for natural products has increased its economic importance, providing opportunities for sustainable farming. *C. aromatica* thrives in tropical and subtropical climates, particularly in Northeast India, where favorable conditions support its cultivation. Sustainable propagation through micropropagation techniques can help preserve genetic diversity while meeting market demands. Future research is needed to further explore its therapeutic potential and integrate it into modern healthcare practices. Hence, the present review was designed to provide a comprehensive view of the pharmacological properties of *Curcuma aromatica* and to explore the potential for its sustainable cultivation in the Northeastern region of India, with a focus on enhancing its economic and cultural significance.

1. Introduction

C. aromatica Salisb also known as wild turmeric, is a perennial herb of the ginger family (Zingiberaceae), recognized for its rhizomatous growth, camphoraceousodor and light yellow-orange rhizomes. Native to South and Southeast Asia, particularly India, it is widely distributed in regions such as the Western Ghats and Northeastern Himalayas, where it thrives in the wild (Dhiman *et al*., 2023). This plant has a long history of use in traditional medicine, especially in Ayurveda, where it has been employed for over 6,000 years to treat a variety of ailments including skin diseases, digestive issues and infections (Ravindran *et al*., 2007; Mohanty *et al*., 2015). The rhizomes are rich in bioactive compounds like terpenoids, flavonoids and essential oils, which exhibit significant pharmacological properties, including anti-inflammatory, antibacterial and anticancer effects (Kojima *et al*., 1998; Sharma *et al*., 2020).

In addition to its medicinal uses, *C. aromatica* is also valued in the cosmetic and food industries for its aromatic and antioxidant properties. Its use in skincare products is attributed to its ability to enhance skin tone and texture, reduce inflammation and promote overall skin health (Sikha *et al*., 2015). The rising demand for natural and organic products has further boosted its economic significance, making it a valuable resource for sustainable farming and modern healthcare applications (Panich *et al*., 2010; Hu *et al*., 2011). Further research is needed to fully understand and utilize the plant's bioactive compounds, ensuring its continued importance in traditional medicine and potential integration into contemporary therapeutic practices (Hasmeda *et al*., 1996).The rising demand for natural and organic products has increased the economic significance

of *C. aromatica*, providing opportunities for sustainable farming in regions like Northeast India, where it is cultivated extensively (Tushar *et al.*, 2010).

2. Influence of cultural heritage

C. aromatica Salisb is well regarded in India for its various traditional uses, particularly in Northeast India. It is recognized as a tonic, carminative, astringent. The plant is used to treat bruises, corns, sprains and to enhance complexion. A paste made from the rhizome with milk is commonly applied to treat dysentery and gastric ailments. Additionally, the aqueous extracts of the rhizomes are used to alleviate indigestion, rheumatism and dysentery (Rao, 1981; Jain, 1995).

In Northeast India, particularly among the Khasi and Garo tribes of Meghalaya, *C. aromatica* holds significant cultural and medicinal value. The tribes use a paste of the rhizomes, consumed with water, to prevent helminth infections. The rhizomes are also traditionally used to assist in expelling a stillborn baby from the womb and to treat various ailments like digestive disorders, skin diseases, menstrual irregularities and mental health conditions. The leaves of the plant are also used to heal wounds and fractured bones (Kirtikar *et al.*, 1978; Dhiman *et al.*, 2023).*C. aromatica* is deeply integrated into the traditional healthcare practices of Northeast India, where it is utilized for both preventive and curative purposes. The plant's versatile applications in local medicine highlight its importance in folk medicine and cultural practices in the region

3. Medicinal and therapeutic values

C. aromatica Salisb is highly valued in Ayurveda and traditional medicine for its wide range of therapeutic properties. It is commonly used to treat skin conditions, as well as diseases related to the cardiovascular and respiratory systems. In cosmetic formulations and traditional medicinal practices, it is recognized for its anti-inflammatory properties, its ability to enhance blood circulation, improve complexion, remove blood stasis and its potential in cancer treatment. Plant rhizomes are often combined with astringents and aromatic substances to treat various conditions, such as bruises, sprains, hiccups, bronchitis, cough, leucoderma and skin eruptions. The paste of rhizomes is a popular home remedy for headaches and is also applied in cases of snake bites due to its purported antidote properties. These diverse medicinal applications underscore the plant versatility and its integral role in traditional health practices (Ravindran *et al.*, 2007).

4. Chemical constitutents

C. aromatica Salisb is rich in various bioactive compounds. The primary constituents include curcumin, which ranges from 3% to 7% in the dried rhizome and is known for its antioxidant and anti-inflammatory properties (Khan *et al.*, 2016). The essential oil of *C. aromatica* contains volatile compounds such as tumerone, with concentrations typically between 2% and 6%, and zingiberene, around 10% (Arutselvan *et al.*, 2009). Additionally, the plant contains demethoxycurcumin and bisdemethoxycurcumin, which are curcumin derivatives with potential therapeutic benefits (Huang *et al.*, 2017). These constituents contribute to the plant's therapeutic potential and distinctive aroma.

C. aromatica essential oil contains major constituents like camphor (26.32%) and borneol (16.45%), with notable antioxidant activities (Choudhary *et al.*, 1996). Its methanol extract shows

strong free radical scavenging, particularly against DPPH and superoxide radicals (Archana *et al*., 2005). Polar extracts' high total phenolic content contributes significantly to its antioxidant potential (Madsen *et al*., 1996; Decker, 1997). Variations in essential oil composition are influenced by factors like harvest season and geographical origin (Burt, 2004).

5. Pharmacological effects

C. aromatica Salisb, widely recognized for its diverse bioactive compounds, demonstrates a range of pharmacological effects. Traditionally, its rhizomes have been used for their anti-inflammatory, antibacterial and anticancer benefits (Kojima *et al.*, 1998). The plant addresses digestive issues, skin conditions, and liver ailments in various traditional medicine systems. Additionally, it is used to treat dyspepsia, gout, wounds and infections and is applied externally for conditions such as scabies and smallpox (Dhiman *et al*., 2023; Kirtikar *et al*., 1978). The essential oils and curcumin from *C. aromatica* are noted for their antimicrobial, antifungal and anticancer properties, reinforcing its role in cancer therapy and its inclusion in therapeutic and cosmetic products (Sharma *et al.*, 2020; Hasmeda *et al*., 1996). These pharmacological attributes highlight the plant potential in modern medicine and its significance in traditional and contemporary health practices.

C. aromatica Salisb. demonstrates a wide range of pharmacological activities. Its anti-inflammatory properties are evidenced by both aqueous and alcoholic extracts, which show significant activity in mice models, affecting arachidonic acid metabolism and cyclo-oxygenase pathways (Sikha *et al.*, 2015). The rhizome's wound healing potential has been confirmed in rabbit studies, showing effectiveness in excision wound models with topical applications (Ravindran *et al*., 2007). Germacrone, a major chemical constituent exhibits anti-tumor effects by inducing apoptosis and cell cycle arrest in glioma cells (Hasmeda*et al.*, 1996). This diverse chemical compound has become a point of significant attention in recent years due to its wide range of pharmacological properties, including anticancer, anti-inflammatory, antiviral, antioxidant, anti-adipogenic, anti-androgenic, antimicrobial, insecticidal, and neuroprotective effects (Riaz *et al*.,2020). Germacrone has demonstrated efficacy in inducing cell cycle arrest and promoting apoptosis across various cancer types, such as breast, brain, liver, skin, prostate, gastric, and esophageal cancers, through the regulation of multiple cellular signaling molecules and pathways implicated in cancer progression (Riaz *et al*., 2020). The oil from *C. aromatica* also shows promising results in inhibiting hepatoma growth in mice, with substantial tumor inhibitory rates (Rao, 1981). Anticancer activity has been demonstrated with aqueous extracts inhibiting colon carcinoma cell proliferation (Hu *et al.*, 2011). It’s mosquito-repellent activity is notable, with ethanol extracts showing effective repellency and larvicidal properties against *Aedes aegypti* (Sharma *et al*., 2020). Additionally, it has antiplatelet activity, with curcumin demonstrating strong inhibition of platelet aggregation (Kirtikar *et al.*, 1978). Curcumin possesses the capability to inhibit both acute and chronic inflammation. It exerts its anti-inflammatory effects by decreasing histamine levels and potentially enhancing the production of natural cortisone by the adrenal glands (Alok *et al*.,2015). The ethanolic extract also exhibits significant antitussive effects in a sulfur dioxide-induced cough model (Marina *et al*., 2008). Its antioxidant and free radical scavenging activities are highlighted by its potent effects in DPPH and superoxide radical-scavenging assays (Sikha *et al*.,

2015). The extracts also protects against UVA-induced melanogenesis and nephrotoxicity, showing their broad therapeutic potential (Sharma *et al*., 2020).

6. Cultivation Practices

It is well-suited to cultivation in tropical and subtropical climates and in northeast India, it is commonly grown in agroforestry systems or as a companion crop with other agricultural plants. The land should be ploughed 4 to 5 times to achieve a fine tilth for optimal soil conditions. Raised beds measuring 1 meter in width, 15 centimeters in height, and 3 meters in length are constructed with a spacing of 40 centimeters between them. In a one-hectare area, approximately 2000 beds of 3m x 1m size are required. The recommended planting distance is 30 cm x 30 cm within the bed system, with each 3m x 1m bed able to hold 40 plants. Maintenance involves regular weeding, mulching, and irrigation during dry periods to ensure healthy growth throughout the growing season (Nair, 2019). The plant thrives during the summer monsoon season, displaying rapid and vigorous growth. Its fragrant and attractive appearance is recognized, with a strong subterranean rhizome. In late autumn, the foliage dies off, leaving the rhizome dormant through the winter. By early spring, the plant begins to flower, producing white blooms with orange leaves at the base of the rhizome. The blooming stalks, approximately 20-25 cm in length, are adorned with large, colorful bracts that are pink-tipped. Fully matured plants can reach a height of around 90 cm (Dhiman *et al*., 2023).

I. Site selection

C. aromatica thrives in well-draining, fertile soils with ample sunlight. Research indicates that the plant achieves optimal growth in terms of height, number of leaves per plant, number of fingers per rhizome, and the length and weight of individual rhizomes, when grown in conditions with full sunlight. This contrasts plants grown in open spaces with less direct sunlight, with significantly lower growth parameters (Hazarika *et al*., 2009). The plant requires well-drained, friable sandy loam soil enriched with organic matter for optimal growth and development. Proper drainage is essential to minimize the risk of disease incidence.

II. Sustainable Propagation

It is primarily propagated through rhizome cuttings, which are widely used due to their effectiveness in establishing new plants. However, in many South Asian countries, the high demand from pharmaceutical industries has placed significant pressure on wild populations, leading to concerns about overharvesting and conservation (Kumar & Sikarwar, 2002). To address the challenges associated with commercial cultivation and to preserve genetic diversity, the development of optimized micropropagation protocols has emerged as a promising solution. Micropropagation techniques offer a sustainable approach by enabling the large-scale production of plants in controlled environments while safeguarding the species genetic integrity (Sharmin *et al*., 2013). For large-scale production of *C. aromatica*, micropropagation predominantly utilizes *in vitro* microrhizome production from rhizome explants, facilitating the generation of disease-free plantlets. This method is regarded as optimal for large-scale propagation and germplasm preservation. The process may involve direct organogenesis from axillary buds or rhizome sprouts, or indirect organogenesis through callus induction, depending on the chosen protocol (Brijesh and Ajjappala, 2023). *Curcuma aromatica* is propagated through rhizome cuttings, planted at a depth of

about 5-10 cm during the rainy season (Hazarika *et al*., 2009). It can be intercropped with crops such as rice, maize, and sugarcane, which helps enhance soil fertility and control weed growth (Kumar & Sikarwar, 2002). Harvesting of the rhizomes typically occurs 8-10 months after planting, once the foliage has begun to die back (Sharmin *et al*., 2013).

7. **Scope for Cultivation:** The north-eastern region of India presents significant potential for cultivating *Curcuma aromatica* Salisb due to its favorable climatic and ecological conditions. The region's tropical and subtropical climate, with ample rainfall and rich, well-draining soils, provides an ideal environment for the growth of wild turmeric. Additionally, the region's diverse ago-ecological zones support cultivating a wide range of crops, making it suitable for integrating *Curcuma aromatica* into existing agricultural systems.

a) **Favorable Climate**: The humid and temperate climate of north-eastern India, with its substantial rainfall and moderate temperatures, supports the optimal growth of *Curcuma aromatica*. The plant thrives in environments with well-distributed rainfall and temperatures ranging from 20°C to 35°C (Hazarika *et al*., 2009).

b) **Agroforestry Systems**: The region's traditional agroforestry practices align well with the cultivation of *Curcuma aromatica*. It can be integrated into existing systems or grown as a companion crop with staple crops like rice, maize, and sugarcane, enhancing soil fertility and reducing weed growth (Kumar & Sikarwar, 2002).

c) **Economic Potential**: The increasing demand for *Curcuma aromatica* in the pharmaceutical, cosmetic, and culinary industries presents a significant economic opportunity for northeastern India. Leveraging the region's unique biodiversity and traditional knowledge can lead to the production of high-quality, value-added products, thereby enhancing the economic potential of cultivating this plant.

d) **Conservation and Sustainability**: The development of sustainable cultivation practices and micropropagation techniques can address issues related to overharvesting and conservation, ensuring the preservation of the plant's genetic diversity while meeting market demands (Sharmin *et al*., 2013).

8. **Conclusion:**

*Curcuma aromatica*Salisb, commonly known as wild turmeric, is a perennial herb with significant cultural and economic importance in South and Southeast Asia, particularly in Northeast India. Its extensive use in traditional medicine and increasing demand in pharmaceutical, cosmetic, and culinary industries underscore its value. The plant thrives in the tropical and subtropical climates of Northeast India, benefiting from the region's favorable weather and agroforestry systems. Sustainable cultivation practices, including optimized micro-propagation, are crucial to address overharvesting concerns and preserve genetic diversity. With its diverse therapeutic properties, from anti-inflammatory to antioxidant effects, *Curcuma aromatica* presents both cultural significance and economic potential, making it a promising candidate for expanded cultivation and integration into modern health practices.

Disclaimer (Artificial intelligence)

Author(s) hereby declare that generative AI technologies such as Large Language Models (ChatGPT 4o) have been used for improving the language of the manuscripts.

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