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Review Article

Curcuma caesia (Zingiberaceae): a natural antioxidant agent

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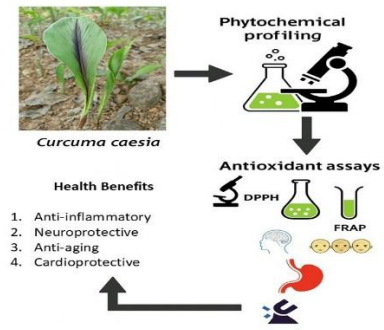
Abstract: *Curcuma caesia* Roxb. (black turmeric), a lesser-known member of the Zingiberaceae family, is gaining scientific attention for its remarkable antioxidant potential. This review consolidates existing literature on its phytochemistry, pharmacological properties, and therapeutic relevance, with a special focus on antioxidant mechanisms. Its rich phytoconstituent profile like curcuminoids, phenolics, flavonoids and essential oils confers significant free-radical scavenging capacity, suggesting potential applications in nutraceutical, cosmeceutical, and pharmaceutical domains.



Graphical abstract

Keywords: *Curcuma caesia*, Zingiberaceae, Antioxidant, Phytochemicals, Free-radical scavenging, Natural therapeutics

Introduction

Documenting natural antioxidant agents is crucial (Gulcin, 2025), because it preserves valuable ethnopharmacological knowledge, validates traditional uses through scientific evidence, and creates a foundation for developing safe, plant-based therapeutics (Taïbi et al., 2020; Dzobo, 2022; Pirintsos et al., 2022; Pirintsos et al., 2022). With oxidative stress being a major contributor to chronic diseases such as cancer, diabetes, and neurodegeneration (Uttara et al., 2009; Chen et al., 2012; Reddy, 2023)), identifying and characterizing natural antioxidants like *Curcuma caesia* (Figure 1) can guide researchers toward affordable, sustainable alternatives to synthetic compounds (Zujko and Witkowska, 2023; Blagov et al., 2024). Proper documentation also aids in biodiversity conservation, supports cultivation and commercialization efforts, and ensures that future generations can benefit from these bioresources while encouraging equitable sharing of benefits with indigenous communities who have safeguarded this knowledge for centuries (Alves and Rosa, 2007; Heinrich et al., 2020; Chaachouay and Zidane, 2024). *Curcuma caesia* Roxb., commonly known as black turmeric or *kali haldi* (Ibrahim et al., 2023), is a perennial rhizomatous herb native to the Indian subcontinent and distributed across the Indo-Burma biodiversity hotspot (Sahu et al., 2016; Das et al., 2024). It thrives in moist deciduous forests, shaded undergrowth, and subtropical regions. Morphologically, it is distinguished by its bluish-black rhizome, aromatic odour, and lanceolate leaves with a characteristic purple band in the midrib region (Paw et al., 2020). Traditionally, the rhizomes are harvested during late autumn and used in folk medicine and rituals, making it both a medicinal and cultural resource. Present short communication draw attention towards its antioxidant activity, cultivation, and utilization.

Traditional and ethnomedicinal significance

In Ayurveda, kali haldi is described as katu-tikta rasa, warming in nature, and used for balancing *vata* and *kapha* doshas. Tribal communities employ it for relief from respiratory disorders, skin diseases, gastric complaints, and as a general tonic. Its ritualistic value is evident during auspicious ceremonies, where it is considered a protective herb against evil influences. Such multifaceted usage highlights its socio-cultural and pharmacological relevance (Banerjee et al., 1978; Arulmozhi et al., 2006; Rajamma et al., 2012; Sahu et al., 20016).

Antioxidant relevance and research need

Oxidative stress plays a crucial role in chronic diseases including diabetes, neurodegeneration, cardiovascular disorders, and cancer (Sharifi-Rad et al., 2020). Natural antioxidants from plants are preferred over synthetic analogs due to their safety and compatibility (Lourenço et al., 2019). *Curcuma caesia*, being chemically rich in phenolic curcuminoids and essential oils, demonstrates strong free-radical scavenging ability in *in vitro* assays (DPPH, ABTS, FRAP). Despite promising preliminary findings, systematic reviews on its antioxidant potential remain scarce necessitating a consolidated evaluation (Devi et al., 2015).

Figure 1: Leaves of *Curcuma caesia*

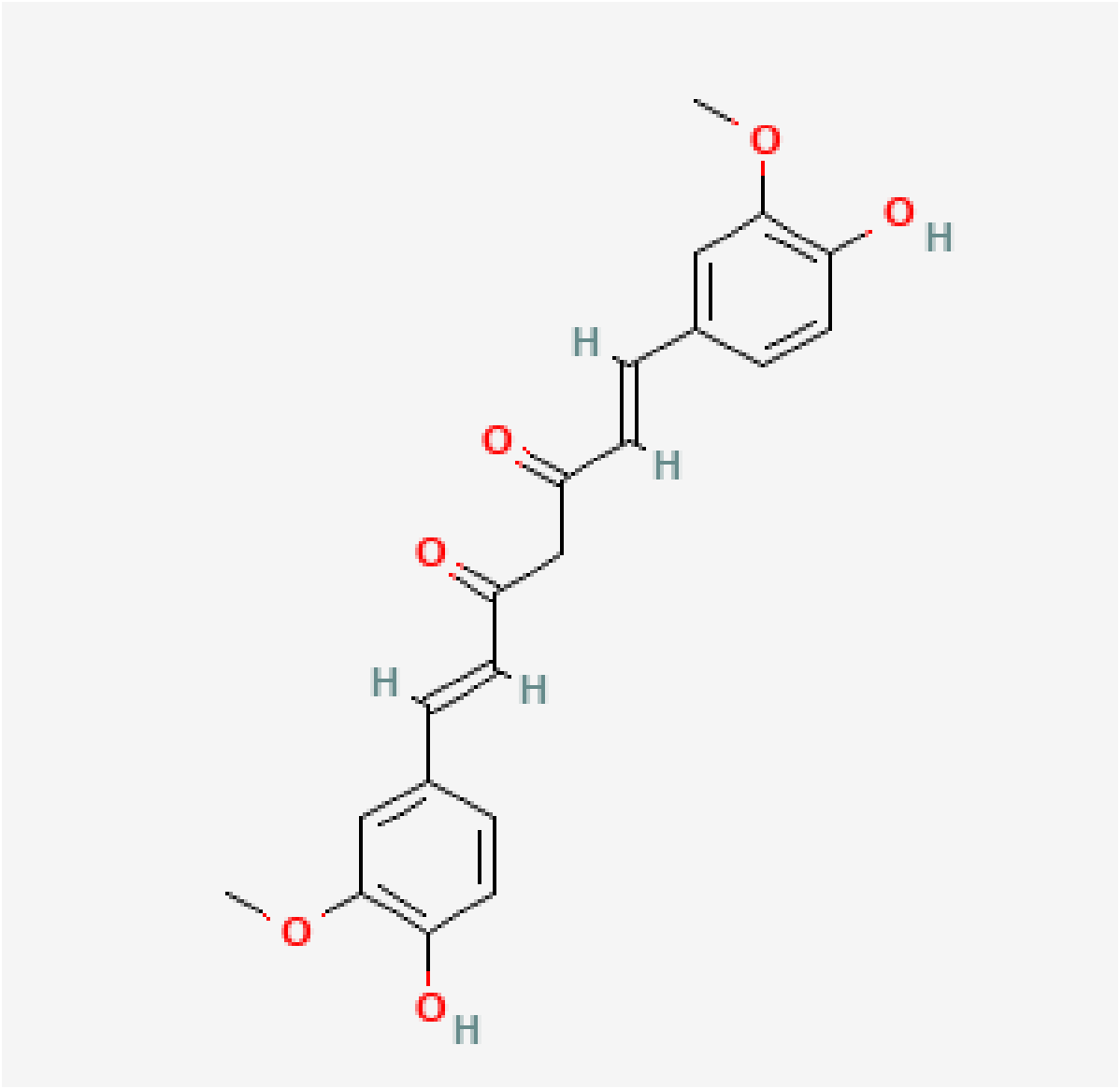


Figure 2: Chemical structure of curcumin (Source: PubChem)

Pharmacological and therapeutic potential

Beyond antioxidant activity, *C. caesia* shows anti-inflammatory, antimicrobial, hepatoprotective, and wound-healing effects. Its antioxidant potential synergies with these properties by reducing oxidative tissue damage. Emerging evidence suggests neuroprotective effects, offering promise for preventing neurodegenerative conditions like Alzheimer's disease. Its essential oils also hold potential as natural food preservatives due to strong antioxidative and antimicrobial synergy (Paliwal et al., 2011).

Phytochemistry

The rhizomes of *C. caesia* are a repository of bioactive metabolites. Major constituents include curcuminoids (curcumin (Figure 2), demethoxycurcumin), phenolic acids, flavonoids, tannins, sesquiterpenes (zingiberene, germacrone), and essential oils rich in camphor and ar-turmerone. Phytochemical screening reports confirm high total phenolic content (TPC) and total flavonoid content

(TFC), both correlating positively with antioxidant capacity. Recent metabolomics approaches have identified unique diarylheptanoids, lending the species with distinct pharmacological profile (Al-Amin et al., 2021; Paudel et al., 2024).

Future aspects

Future research on *Curcuma caesia* should focus on bioassay-guided isolation of its active antioxidant compounds, followed by structural characterization using advanced analytical tools like HPLC, LC-MS, and NMR. *In vivo* studies are needed to confirm its efficacy, safety, and pharmacokinetics in animal models and clinical trials, enabling its translation into nutraceuticals or therapeutic formulations. Additionally, efforts should be made to develop standardized extracts, optimize cultivation and post-harvest practices for sustainable supply, and explore its potential applications in food preservation, cosmeceuticals, and functional health supplements, ultimately positioning *C. caesia* as a commercially viable natural antioxidant resource.

Conclusion

Curcuma caesia is a promising natural antioxidant source with a unique phytochemical composition and multiple health-promoting properties. Its integration into preventive healthcare, functional foods, and herbal therapeutics could help combat oxidative stress-mediated disorders. Multidisciplinary research combining phytochemistry, pharmacology, and biotechnology will be essential to unlock its full potential while ensuring sustainable utilization.

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