

# Traditional uses, phytochemistry and pharmacology of three medicinally potential *Curcuma* species

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## Abstract

The leaves and rhizomes of certain species of *Curcuma* are extensively used in Ayurvedic medicine and as traditional remedies against various ailments. *Curcuma longa*, *C. caesia* and *C. amada* are three important species of the genus *Curcuma*, with wide range of medicinal properties. Biological activities, including antioxidant, antibacterial, and anti-inflammatory properties, as well as presence of several bioactive components have been reported in various discrete literatures. Here we have prepared a comprehensive document to summarize the ethnomedicinal uses, phytochemical constituents, and major pharmacological activities of *C. longa*, *C. amada*, and *C. caesia*, by pulling together the published information from various authentic sources.

**Keywords:** *C. longa*, *C. amada*, *C. caesia*, curcumin, ethnomedicine, bioactivity.

## 1. Introduction

In India, various plant species are being used medicinally for centuries due to their therapeutic qualities. India is home to numerous traditional medicinal systems including Siddha, Unani, Ayurveda, with a broad diversity of ethnomedicinal resources. Almost all civilizations have history of using plant-based treatments and many nations devote 40% to 50% of their whole health budget to the development of new medications (Fuloria *et al.*, 2022).

The *Curcuma* genus belongs to Zingiberaceae family, is a rhizomatous annual or perennial herb. Linnaeus created the genus *Curcuma* in his 1753 book Species Plantarum (Sudeepthi *et al.*, 2014). The majority of the 120 species of this genus have already been mentioned in various literatures (Kress *et al.*, 2022). *Curcuma longa* L., *C. aromatica* Salisb, *C. angustifolia* Roxb, *C. zanthorrhiza* Roxb., *C. amada* Roxb., *C. caesia* Roxb. and *Curcuma zedoaria* (Christm.) Roscoe, are common species that can be found distributed around India and the world. Many species in this genus have significant therapeutic potential that can be used to treat a wide range of medical conditions, including skin disorders, hepatic disorders, cough, chest pain, rheumatism, and diabetes (Saikia and Borthakur, 2010).

*C. longa* is commonly known as haldi in India and turmeric in English. The rhizome is naturally yellow in color due to presence of bioactive compound curcumin and its analogs (Siju *et al.*, 2010). The world's tropics and subtropics are home to the turmeric plant. Although the

origin of the plant is unknown, it is said to have started in South-east Asia, most likely in India (Fuloria *et al.*, 2022). The plant is cultivated throughout India. More than 80% of the world's output of turmeric is produced in India, which is followed by China, Myanmar, Nigeria, and Bangladesh. These nations also produce high-quality essential oils and curcumin from turmeric (Dei and Ghidoni 2019). Turmeric is highly valued in India due to its incredible medicinal qualities (Campbell *et al.*, 2019). *C. caesia*, also referred to as black turmeric (English) or kali haldi (Hindi), thrives on moist, rich, clayey soils. It came from the Himalayan region, including South East Asia and India. Due to high therapeutic value, *C. caesia* has been exploited indiscriminately from their natural habitat which has pushed it under the category of critically endangered species (Behar *et al.*, 2014; Kumar *et al.*, 1998). *C. amada* having physical characteristics with ginger (*Zingiber officinale*), tastes more like raw mango (*Mangifera indica*). *C. amada* is cultivated in a variety of climates, although the hot climate is ideal for the plant's optimum growth. Keeping in view the tremendous pharmacological potentials of *Curcuma* spp, we have prepared a precise review of the ethnomedicinal uses, phytochemical constituents, and major pharmacological activities of three medicinally potential *Curcuma* species, viz. *C. longa*, *C. amada*, and *C. caesia*.



## 2. Traditional uses

*C. longa* is used traditionally to treat dental problems, digestive disorders like indigestion, ulcers, and upper abdominal discomfort or pain, as well as to lessen the hallucinogenic effects of hashish and other psychoactive drugs (Fuloria *et al.*, 2022). *C. longa* is also well-described in Indian material medicine (Dravyaguna Shastra), where Hindu girls apply it daily on their foreheads as part of their beauty routine. One of the most important aspects of Hindu ritual is the application of *C. longa* paste on the bride (Paranjpe and Pranjpe, 2001). Tribal women from Assam apply a fresh rhizome paste to treat skin infections as well as to brighten their skin. *C. longa* helps to lower blood clotting and blood sugar level (Zhang *et al.*, 2013). Turmeric powder mixed with calcium hydroxide is indeed a popular home remedy for treating sprains and swelling induced by wounds that can be applied directly to the injury site (Fuloria *et al.*, 2022).

Numerous species in this genus are valuable as medicines, dyes, and spices. The oldest healthcare system in India, Ayurveda, attributes numerous benefits to *C. amada* rhizomes as a carminative, digestive, stomachic, demulcent, vulnerary, febrifuge, diuretic, expectorant, anti-inflammatory, appetizer, alexeteric, antipyretic, aphrodisiac, and laxative (Warrier, 1993). Bioactivity of *C. amada* against inflammation due to injuries, asthma, itching and biliousness were reported previously (Sastri, 1950). Effectiveness of *C. amada* rhizomes against ulcers on the male genitalia, gleet, scabies, lumbago, mouth and ear inflammation, and stomatitis have been documented in numerous reports (Kirtikar and Basu, 1984; Hussain *et al.*, 1992; Warrier *et al.*, 1994).

The herbal systems of Ayurveda, Unani, and Siddha have documented *C. caesia* as a medicinal herb (Ranemma and Reddy, 2017). The fresh leaves of *C. caesia* are eaten directly or given as a drink to treat cough (Awang-Kanak *et al.*, 2018). It is mixed with milk or honey to be consumed twice daily for treatment of infertility, irregular menstrual cycle, and weakness and to induce longevity (Verma *et al.*, 2010). Bites from snakes or scorpions can also be treated with rhizome paste of *C. caesia* (Bhardwaj *et al.*, 2023). During marriage and engagement rituals, tribal women use powdered *C. caesia* rhizome as a face mask to enhance beauty (Paliwal *et al.*, 2011). Crushed fresh rhizome is applied as a paste for strains and bruises and as a migraine remedy (Sahu and Saxena, 2018). Additionally, it is eaten orally with water to treat bloating and stomach pain (Sahu and Saxena, 2018). An extract made from dried rhizomes is consumed for asthma treatment (Pandey and Lal, 1999).

### **3. Phytochemistry**

From 32 *Curcuma* spp. 719 components, including terpenoids, flavonoids, phenylpropene derivatives, alkaloids, diphenylalkanooids, steroids, and other substances, have so far been extracted and identified (Sun *et al.*, 2017). Over 235 phytoconstituents, mostly polyphenols and terpenoids, were discovered in the rhizome (Table 1). The most prevalent polyphenols are curcuminoids, which are composed primarily of curcumin (80%). There are 14 more ingredients in addition to the 109 sesquiterpenes, 68 monoterpenes, 22 diarylheptanoids and diarylpentanoids, 8 phenolics, 5 diterpenes, 4 sterols, 3 triterpenoids, and 2 alkaloids (Fuloria *et al.*, 2022).

**Table 1:** Qualitative phytochemical evaluation of *C. longa*, *C. amada* and *C. caesia* (Borah *et al.*, 2016 ; Eze-Steven *et al.*, 2021 ; Grover *et al.*, 2021 ; Hait and Deepal., 2018 ; Sutar *et al.*, 2020 ; Ysdav and Saravanan, 2019).

Plant	Extraction solvent	Alkaloid	Flavonoid	Saponin	Tannin	Glycosides	Terpenoids	Phenol	Steroid
<i>C. longa</i>	Methanol	+	+	+	+	+	+	+	+
	Ethanol	+	-	+	+	+	+	-	-
	Acetone	+	+	+	+	+	+	+	-
	Ethyl acetate	+	+	+	+	+	+	+	+
	Chloroform	-	-	+	-	+	+	-	+
	Hydroalcohol	+	+	+	+	+	+	+	+
<i>C. amada</i>	Methanol	-	+	+	-	-	+	-	+
	Ethanol	+	+	+	+	+	+	+	+
	Ethyl acetate	-	+	-	+	-	+	-	+
	Chloroform	-	-	-	+	-	+	-	+
	Aqueous	-	+	+	+	-	+	-	-
	Petroleum ether	+	-	+	+	-	+	-	+
	Acetone	+	+	+	+	+	+	+	-
<i>C. caesia</i>	Metanol	-	+	+	+	+	+	-	+
	Ethanol	+	+	+	+	+	+	NA	-
	Ethyl acetate	-	+	-	NA	-	NA	-	NA
	Chloroform	-	+	-	+	+	+	-	+
	Aqueous	+	-	+	+	+	+	-	-

(+) Indicates 'Presence'; (-) Indicates 'Absence'

#### 4. Pharmacological activities

##### 4.1 Antioxidant activity

Antioxidants shield the body from free radical damage. Curcumin and its three derivatives (dimethoxy curcumin, bisdemethoxycurcumin, and diacetyl curcumin) were reported for their antioxidant properties (Faizal *et al.*, 2009). The curcumin component of *C. longa* and its water and fat-soluble derivatives show powerful anti-oxidant capacity, comparable to vitamins C and E. According to previous study curcumin is eight times more effective than vitamin E at reducing lipid peroxidation (Toda *et al.*, 1985).

The ability to scavenge H<sub>2</sub>O<sub>2</sub> was the highest in the methanolic extract of rhizomes and leaves of *C. amada*, followed by chloroform and aqueous extracts. Rhizomes demonstrated more activity. Chloroform and aqueous extracts were the most effective at inhibiting the production of nitric oxide and superoxide *in vitro*, followed by methanolic extracts of both leaves and rhizomes of *C. amada* (Sudeepthi *et al.*, 2014).

Methanolic extract of rhizome of *C. caesia* is proven to be an excellent source of natural antioxidant (Liu *et al.*, 2013). When compared to *C. zedoaria*, protein extracts from *C. caesia* rhizomes showed lower inhibitory concentrations (IC50 values), indicating stronger antioxidant activity (Angel *et al.*, 2013). Additionally, methanolic extract (50% concentration) of *C. caesia* leaves showed antioxidant activity, with thiobarbituric acid-reactive substances (TBARS) inhibition levels ranging from 47.24 to 73.30% (Ho *et al.*, 2018). The ability of a methanolic extract of the *C. caesia* rhizome to act as an antioxidant by effectively scavenging free radicals in Wistar rat models of diabetes induced by streptozotocin (STZ) was also reported (Majumder *et al.*, 2017).

#### 4.2 Anticancer activity

Curcumin slowed down tumour growth and cell division in prostate and colon cancer. Additionally, curcumin of *C. longa* could reduce the activity of a number of common carcinogens and mutagens in various cell types in both *in vivo* and *in vitro* investigations (Dorai *et al.*, 2001).

Methanolic extract of leaves and rhizomes of *C. amada* were tested for studying anti-cancer activity against breast cancer. The diphenylamine method for testing the anti-cancer activity revealed that the steroid and terpenoid compounds of rhizome and leaf extracts of *C. amada* prompted cell death in MCF-7 and MDA MB 231 breast cancer cell lines (Sivaprabha *et al.*, 2015).

*C. caesia* methanolic extract of rhizomes showed positive anticancer activity against Ehrlich's ascites carcinoma (EAC) in mice by notably reducing the tumor weight, tumor volume, viable cell count and rising the lifespan percentage (57.14 and 88.09 %) of EAC-treated mice (Karmakar *et al.*, 2013).

#### 4.3 Antimicrobial activity

The *C. longa* treated rabbit group had a significantly greater mean value for wound contraction, and therefore, revealed decreased inflammation and a rising tendency in collagen formation. Another study identified the phytoconstituents such as alkaloid, flavonoid, anthocyanin, steroids, and coumarin in *C. longa* extracts and demonstrated the synergistic combinatorial impact of copper metal ions with aqueous extracts of *C. longa* against *Paenibacillus popilliae*, a known food spoilage bacterium (Jassal *et al.*, 2015).

Methanol, hexane, ethylacetate, chloroform and acetone extracts of *C. amada* were found to be highly antibacterial against pathogenic bacteria *Bacillus cereus*, *Enterococcus faecalis*, *Listeria monocytogenes*, *Micrococcus luteus*, *Salmonella typhi*, and *Staphylococcus aureus* (Policegoudra *et al.*, 2007a & 2007b). Some components of *C. amada* volatile oils like, pinene and myrcene showed antifungal activity against *Fusarium. falcatum*, *F. moniliforme*, *Aspergillus niger*, *A. terreus* and *Curvularia palliscens* (Singh *et al.*, 2002).

Acetone extract of *C. caesia* showed the highest activity against *S. aureus*, while chloroform extract showed the highest inhibitory action against *Serratia marcescens* (Jose and Thomas, 2014). *Mycobacterium tuberculosis* (Mtb H37Rv) and six multidrug-resistant (MDR)

clinical strains of Mtb, which were isolated from sputum samples of pulmonary tuberculosis (TB) patients, were successfully eradicated by an ethanolic extract of *C. caesia* rhizome (Gupta *et al.*, 2018).

#### 4.4 Antidiabetic activity

Compared to curcuminoids or sesquiterpenoids alone, the ethanolic extract of *C. longa* with both of these compounds was found to be more hypoglycemic (Nishiyama *et al.*, 2005). Human pancreatic amylase was blocked by both the isopropanol and the acetone extract of *C. longa*, which lessened starch breakdown and lowered blood glucose levels (Ponnusamy *et al.*, 2010).

Methanol extract of *C. amada* rhizome had modest hypoglycemic as well as anti-hyperglycemic effects in mice and the extract had no toxic side effects even at a very high dose (650 mg/kg body weight) (Syiem *et al.*, 2011).

The rhizome of *C. caesia* showed potential antidiabetic activity in Streptozotocin (STZ)-induced diabetic rats. It significantly improved body weight and decreased glycosylated haemoglobin (HbA1c), fasting blood glucose (FBG). Oral glucose tolerance test (OGTT) results also showed a normal level in the rats treated with *C. caesia* rhizomes (Majumder *et al.*, 2017).

#### 4.5 Anti-inflammation activity

Curcumin from *C. longa* has been demonstrated to have anti-inflammatory properties in conditions such as chronic anterior uveitis, inflammatory bowel disease, and pancreatitis (Hewlings and Kalman, 2017). An oil-free aqueous extract (COFAE) of *C. longa* showed significant anti-inflammatory effects against acute and chronic inflammation. An extract of *C. longa* was given to rats with arthritis due to collagen dysfunction, and it stopped the degenerative changes in their bones and joints (Sun *et al.*, 2017).

*C. amada* ethanolic extract showed the presence of various chemical constituents with the presence of carbonyl, ester, hydroxyl and olefinic groups. At greater concentration, the extract showed statistically significant dose-dependent anti-inflammatory activity in acute carrageenan-induced rat paw edema model. The extract showed anti-inflammatory activity during different acute stages of inflammation and on the formation of granular tissue (Majumdar *et al.*, 2000).

The strongest albumin denaturation inhibitory action was shown by the leaf essential oil of *C. caesia*, which also had a lower IC<sub>50</sub> value (182.5 g/mL) than the typical sodium diclofenac (906.5 g/mL). Inflammatory disease can be decreased or delayed by inhibition of cyclooxygenase (COX) enzymes linked with inflammatory intermediates such as thromboxanes and prostaglandin. Hexane and methanolic extracts of *C. caesia* have been demonstrated to have anti-inflammatory effect by selectively inhibiting COX-2 and mildly inhibiting COX-1 (Angel *et al.*, 2013).

#### 4.6 Other activities

*C. longa* rhizome powder is added to cow's urine to treat dermatitis and internal itching, while rhizome juice is used as an antiparasitic agent in the treatment of several skin disorders (Paranjpe and Pranjpe, 2001). Curcumin from *C. longa*, with proven antimutagenic, antioxidant,

free radical scavenging, anti-inflammatory, and anti-carcinogenic abilities, protect the skin from detrimental UV-induced impacts (Binic *et al.*, 2013).

Aqueous rhizomes extract of *C. amada* applied to the rabbits, in 200 mg/kg dose, showed significant antipyretic activity (Kumar *et al.*, 2015). *C. amada* also showed other activities like anti-ulcer, anti-tubercular, anti-hyperglycemic, and analgesic activity (Kanase and Khan, 2018). *C. amada* was found to act as Central nervous system (CNS) depressant, because of its ability to slow down the brain activity making them useful for treating anxiety, panic, acute stress reactions and sleep disorder.

In addition, *C. caesia* was reported to purify blood, to treat cancer, inflammatory illnesses, ulcers, dermatitis, excessive cholesterol, diabetes, irregular menstruation, stomach pain, and ulcerative colitis (Arulmozhi *et al.*, 2006 ; Pandey and Chowdhury, 2003 ; Sarangthem and Haokip, 2010; Kagyung *et al.*, 2010 ; Hait *et al.*, 2019).

## 5. Conclusion

Most of the traditional claims regarding the pharmacological properties of *C. longa*, *C. amada*, and *C. caesia* have now been validated in various scientific investigations both *in vitro* and *in vivo*. The rhizomes of the all three *Curcuma* spp. have remarkable bioactive properties. Due to its possible health advantages, all three species of *Curcuma* genus are now gaining attention from the researchers. These three species of *Curcuma* have the potential to be investigated as a natural complementary and alternative health therapy with promising prospective for the pharmaceutical industries. Here, we have precisely documented the medicinal properties and phytochemistry of these three species based on published information. However, there is considerable research gap in the investigation of stress response of these species in changing climate. Specific reaction of these species towards various stress factors in terms of growth and production of pharmacologically potential secondary metabolites as well as their bioactivity are yet to be known sufficiently.

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