

AN OVERVIEW OF MEDICINAL VALUE OF *CURCUMA* SPECIES

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ABSTRACT

Curcuma is a genus of about 100 accepted species in the family *Zingiberaceae* that contains such species as turmeric and Siam tulip. They are native to Southeast Asia, southern China, ISSN (Online): 2319-7064 ISSN (Online): 2319-7064 naturalized in other warm parts of the world such as Tropical Africa, Central America, Florida, and various islands of the Pacific, Indian, and Atlantic Oceans. Few known species of *Curcuma* with reported pharmacological activity are *Curcuma longa*, *Curcuma aeruginosa*, *Curcuma pseudomontana*, *Curcuma aromatica*, *Curcuma xanthorrhiza*, *Curcuma zedoaria*, *Curcuma angustifolia*. Among them, *C. longa* is the one species extensively studied and has ancient traditional medicinal uses. These *Curcuma* species have been used in traditional medicine as a household remedy for various diseases, including biliary disorders, anorexia, cough, diabetic wounds, hepatic disorders, rheumatism, and sinusitis. For the past few decades, extensive work has been done to establish the biological activities and pharmacological actions of *Curcuma* species and its extracts. This review article is created with an intention to give an overview on the reported research carried out on the *Curcuma* species such as anticancer activity, antitumor, antitubercular, antibacterial, antimicrobial, toxicity activity, and wound healing. And also, these *Curcuma* species can be considered as herbal medicinal plant having a plethora of research opportunities based on its traditional use and biological activity.

Keywords: Curcumin, *Curcuma longa*, Anticancer, Antibacterial, Traditional use, Pharmacological activity.

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INTRODUCTION

Although modern medicine has been routinely used in the treatment of various diseases, it is <100 years old. The genus was first established by Carl Linnaeus in 1753. The name *Curcuma* is derived from the Arabic word kurkum, meaning "yellow," which refers to the color of the rhizome. Traditional medicine, in comparison, has served mankind for thousands of years and is quite safe and effective. The mechanism or the scientific basis of traditional medicine, however, is less well understood. Throughout the Orient, *Curcuma* species is traditionally used for both prevention and therapy of diseases. Modern *in vitro* studies reveal that *Curcuma* species is a potent antioxidant, anti-inflammatory, antimicrobial, and anticancer agent [1]. India is popularly known as the "Spice Bowl of the World" as a wide variety of spices with premium quality is grown in the country since ancient times. However, among all those ancient spices, one which is virtually associated and intertwined with all individuals in issues related to food as well as life, so far as aroma, taste, flavor, color, society, religion, economy, ecology, and emotion is concerned, which is turmeric. Turmeric not only adds golden grace but also considered as the golden spice and grown almost all over the world, especially in India, Bangladesh, Burma, China, Indonesia, Myanmar, Nigeria, Pakistan, Sri Lanka, Taiwan, etc. Among these countries, India occupies the first position in area (2,22,000 ha) and in production (11,32,000 MT). Extensively cultivated in Southeast Asia specifically Bengal, China, Taiwan, Sri Lanka, Indonesia. Among these compounds, curcumin, which is mainly found in *Curcuma longa*, is the most widely investigated. In the past several decades, this compound has been studied in numerous comprehensive reviews examining its structure, synthesis, derivatives, and biological activities. Many species of the genus *Curcuma caesia*, *Curcuma rubescens*, *Curcuma amada*, *Curcuma leucorrhiza*, *Curcuma montana*, *Curcuma aromatica*, *Curcuma zedoaria*, *Curcuma angustifolia*, *Curcuma pseudomontana*, *C. longa*, etc. are there with huge diversity and enormous medicinal usage [2]. Table 1 gives the list of all the *Curcuma* species along with their pharmacological activity enlisted in this article.

CURCUMA AERUGINOSA

C. aeruginosa is a perennial plant producing unbranched leafy stems up to 200 cm tall from a large underground rhizome that can be 16 cm long and 3 cm wide [3]. The inflorescence develops from the rhizome, usually before the leaves are produced. The plant is gathered from the wild for use in traditional medicine and as a food. It is often grown in Malaysia as a medicinal plant and is also sometimes cultivated as an ornamental [4].

Pharmacological activity

Antimicrobial activity

Kamazer *et al.* cycloisolongifolene, 8, 9-dehydro formyl (35.29%) and dihydrocostunolide (22.51%) were the major compounds in *C. aeruginosa* oil; essential oils obtained by steam distillation were analyzed by gas chromatography-mass spectrometry (MS). The antimicrobial activity of the essential oils was evaluated against four bacteria: *Bacillus cereus*, *Staphylococcus aureus*, *Escherichia coli*, and *Pseudomonas aeruginosa* [5].

The preliminary results suggest promising antimicrobial properties of *C. aeruginosa*, which may be useful for food preservation, pharmaceutical treatment, and natural therapies.

Anti-inflammatory activity

Asihtriauti *et al.* in their present study evaluated the anti-inflammatory activity of *C. aeruginosa* ethanolic extracts in experimental animals. The topical anti-inflammatory activity was analyzed using croton oil-induced ear edema. Topical application of (*Curcuma aeruginosa* ethanolic extracts (80 mg/ear, 160 mg/ear) reduced ear edema and pro-inflammatory cells (histological analysis) in the tissue and its activity was similar to hydrocortisone 1% (p>0.05). The ethanolic extract showed strong anti-inflammatory activity [6].

C. AMADA

Mango ginger (*C. amada* Roxb.) is a unique spice having morphological resemblance with ginger but imparts a raw mango flavor. The main use

Table 1: The list of all the *Curcuma* species along with their pharmacological activity enlisted in this article

Curcuma species	Pharmacological activity
<i>Curcuma aeruginosa</i>	Antimicrobial[5]
<i>Curcuma amada</i>	Anti-inflammatory [6]
	Antioxidant[9]
<i>Curcuma angustifolia</i>	Anti-inflammatory[8]
	Antitubercular [10]
<i>Curcuma aromatica</i>	Anti-ulcerogenic [12]
	Wound healing[14]
<i>Curcuma caesia</i>	Anticancer [13,15-17]
	Antioxidant [20,21]
	Larvicidal [13,18,19]
<i>Curcuma longa</i>	Smooth muscle relaxant[22]
	Scavenging/antioxidant [23]
<i>Curcuma pseudomontana</i>	Anticancer[30]
	Antimalarial[31]
<i>Curcuma xanthorrhiza</i>	Anticoagulant [32,33]
	Antimicrobial[36]
	Antitubercular[37]
<i>Curcuma zedoaria</i>	Anticancer [38]
	Cytotoxicity activity[47]
	Hepatoprotective[48]
<i>Curcuma zedoaria</i>	Anti-inflammatory [49]
	Antitumor[66]
	Antibacterial/antimicrobial[58]
	Anti-amoebic activity[69]
	Anticancer activity [60,67,68]
	Hepatoprotective activity [70-72]
	Antivenom activity [73]

of mango ginger rhizome is in the manufacture of pickles and culinary preparations. Ayurveda and Unani medicinal systems have given much importance to mango ginger as an appetizer, alexiteric, antipyretic, aphrodisiac, diuretic, emollient, expectorant, and laxative and to cure biliousness, itching, skin diseases, bronchitis, asthma, hiccup, and inflammation due to injuries. The biological activities of mango ginger include antioxidant activity, antibacterial activity, antifungal activity, anti-inflammatory activity, platelet aggregation inhibitory activity, cytotoxicity, anti-allergic activity, hypotriglyceridemic activity, brine shrimp lethal activity, enterokinase inhibitory activity, central nervous system depressant, and analgesic activity. The major chemical components include starch, phenolic acids, volatile oils, curcuminoids, and terpenoids such as difurocumenonol, amadannulen, and amadaldehyde [7].

Pharmacological activity

Anti-inflammatory activity

Ethanol extract of *C. amada* showed the presence of multiple chemical constituents with the presence of hydroxyl, ester, carbonyl, and olefinic groups. The extract showed dose-dependent anti-inflammatory activity, which was found to be statistically significant at higher concentration in acute carrageenan-induced rat paw edema model. That extract shows anti-inflammatory activity at various acute phases of inflammation and on the formation of granular tissue [8].

Antioxidant activity

Policegoudra *et al.* stated that chloroform extract of mango ginger (*C. amada* Roxb.) rhizome was subjected to antioxidant activity-guided decontamination by repeated silica gel column chromatography to obtain a pure form of the antioxidant compound. The structure was inferred by analyzing UV, IR, liquid chromatography-MS, and two-dimensional heteronuclear multiple quantum coherence transfer spectroscopy nuclear magnetic resonance spectral data and named it as "amadannulen," a novel compound. Amadannulen also reported antibacterial activity against both Gram-positive and Gram-negative bacteria tested [9].

Antitubercular activity

Singh *et al.* reported that a labdane diterpene dialdehyde was first time isolated from the chloroform extract of rhizomes of *C. amada*. This compound exhibited antitubercular activity against *Mycobacterium tuberculosis* H37Rv strain in BACTEC-460 assay. It is the first report on isolation and ant mycobacterial activity of this dialdehyde from *C. amada* [10].

C. ANGUSTIFOLIA

C. angustifolia also known as Indian Arrowroot is an attractive ginger with stout underground rhizomes which lie dormant in winters. In early spring, the flowers are produced before the leaves. The shape and color of the bracts are very variable. The inflorescence lasts in full bloom on the plants for about 3 weeks and more. Good for cut flower use with a vase life of 10 days and more for fresh cut blooms. Leaves grow to about 2 ft tall and die down in autumn. East Indian Arrowroot is found in the Himalayas, from Kumaon to NE India and SE Asia, at altitudes of 900–1210 m [11].

Pharmacological activity

Anti-ulcerogenic activity

Rajashekara *et al.* showed that the starch of *C. angustifolia* showed a significant decrease in the volume, increase in the pH, reduced the free acidity of gastric juice, and decreased the peptic activity. The studies were carried out in gastric-induced albino rats. From the above research article, it can be concluded that *C. angustifolia* has anti-ulcer activity [12].

C. AROMATICA

C. aromatica Salisb., mentioned as "Vanaharidra" in Ayurveda, belongs to the "ginger family" *Zingiberaceae*. It is a perennial herb with characteristic aromatic rhizomes used in many traditional systems of medicines in India, China, and other Southeast Asian countries. The rhizome of the plant is rich in alkaloids, flavonoids, curcuminoids, tannins, and terpenoids which are reported to be the reasons for its various pharmacological properties. The extraction of compounds in different solvents shows that the plant contains curdione, neocurdione, and germacrone as its major components. Extensive literature survey showed that the plant has anticancerous, antiobesity, antiacne, antitussive, antioxidant, anti-inflammatory, antidiabetic, and wound healing properties [13].

Pharmacological activity

Wound healing activity

The powdered rhizome of *C. aromatica* exhibited wound healing activity in rabbits. Studies also showed significant wound healing activity in excision wound models, conducted to assess the wound healing activity of topical application of *C. aromatica* rhizome extracts and its cream formulations [14].

Anticancer activity

Curcumin, a potential antioxidant extracted from *C. aromatica*, has been widely studied and showed anticarcinogenic properties in a wide variety of cell lines. A study was conducted to evaluate the anticancer effects of the aqueous extract of *C. aromatica* (AECA) and related molecular mechanisms of *C. aromatica* in human colon carcinoma LS174-T cell line with wild-type p53 used as a model cell. This study suggested that AECA might be effective as an antiproliferative herb for colon carcinoma [13,15-17].

Larvicidal activity

The rhizome extract and its volatile components of the plant are reported for their anti-larvicidal activity. Das *et al.* evaluated mustard (*Brassica sp.*) and coconut (*Cocos sp.*) oil-based rhizome extract oil against mosquitoes and reported protection in both the bases at all the tested concentrations [13,18]. The ethanolic extract of *C. aromatica* showed a protective effect against *Armigeres subalbatus*, *Culex*

quinquefasciatus, and *C. tritaeniorhynchus*. Thus, the extract can be applied as an effective personal protection measure against mosquito bites. The rhizome extract is effective against *Aedes togoi* [19].

Antioxidant activity

The rhizome extracts of *C. aromatica* were found to be effective antioxidant agents. The sesquiterpenoids present in the volatile oil of *C. aromatica* functions as anti-inflammatory, antiviral, and antioxidant agent [20]. The methanol extract of essential oil from the leaves exhibited remarkable superoxide radical scavenging activities [21].

C. CAESIA

C. caesia (family *Zingiberaceae*) is a perennial herb. The plant is distributed throughout the tropical and subtropical regions of the world and is widely cultivated in Asian countries. In India, it is popularly known as "Kala Haldi." There are many reports on the pharmacological effects of *Curcuma* drugs such as their ability to express antitumor, anti-inflammatory, antifungal, and immunological activities.

Pharmacological activity

Smooth muscle relaxant

C. caesia is widely used in India as both an anti-inflammatory and antiasthmatic in Ayurvedic medicine. However, there are no published pharmacological data on *C. caesia* on its potential antiasthmatic activity. Hydroalcoholic extract of *C. caesia* was tested for its relaxant effect in guinea pig trachea and also in the presence of various receptor antagonists and enzyme inhibitors, namely propranolol, 2,5-dideoxyadenosine, methylene blue, glibenclamide, N-nitro-L-arginine, and chymotrypsin. Results suggested that the relaxant action mechanism of *C. caesia* extract may be inhibition of calcium release from intracellular calcium stores as well the calcium efflux from extracellular space. The present data may shed some light on the ethnomedical usage of *C. caesia* in asthma and other vascular disorders [22].

Scavenging activity/antioxidant activity

Karmakar *et al.* evaluated the methanol extract of *C. caesia* rhizome for some *in vitro* antioxidant studies as it is known that many diseases are associated with reactive oxygen species and reactive nitrogen species. Lipid peroxidation and total phenolic content were also measured by standard assay method. The extract showed significant antioxidant activities in a dose-dependent manner. From the above study it is concluded that the methanol extract of *C. caesia* rhizome is a potential source of natural antioxidant [23].

C. LONGA

Turmeric is a spice that has received much interest from both the medical/scientific worlds as well as from the culinary world. Turmeric is a rhizomatous herbaceous perennial plant (*C. longa*) of the ginger family [24,25]. Curcumin (1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6,7-heptadiene-3,5-dione), also called diferuloylmethane, is the main natural polyphenol found in the rhizome of *C. longa* (turmeric) and in others *Curcuma* spp. [24,26]. *C. longa* has been traditionally used in Asian countries as a medical herb due to its antioxidant and anti-inflammatory [24,27]. The plant grows to a height of 3–5 ft. It has oblong, pointed leaves and bears funnel-shaped yellow flowers, peeping out of large bracts. The rhizome is the portion of the plant used medicinally. It is usually boiled, cleaned, and dried, yielding a yellow powder [28].

Chemical composition of turmeric (*C. longa*)

Turmeric contains protein (6.3%), fat (5.1%), minerals (3.5%), carbohydrates (69.4%), and moisture (13.1%). The essential oil (5.8%) obtained by steam distillation of rhizomes has α -phellandrene (1%), sabinene (0.6%), cineol (1%), borneol (0.5%), zingiberene (25%), and sesquiterpenes (53%) [5]. Curcumin (diferuloylmethane) (3–4%) is responsible for the yellow color and comprises curcumin I (94%), curcumin II (6%), and curcumin III (0.3%) [6]. Demethoxy and bisdemethoxy derivatives of curcumin have also been isolated [7].

Curcumin was first isolated [8] in 1815, and its chemical structure was determined by Roughley and Whiting [9] in 1973. It has a melting point at 176–177°C, forms a reddish-brown salt with alkali, and is soluble in ethanol, alkali, ketone, acetic acid, and chloroform [29].

Pharmacological activity

Anticancer activity

Kuttan *et al.* carried out anticancer activity on the rhizomes of turmeric and evaluated through *in vitro* studies using tissue culture methods and *in vivo* in mice using Dalton's lymphoma cells grown as ascites form. Turmeric extract inhibited the cell growth in Chinese Hamster Ovary cells at a concentration of 0.4 mg/ml and was cytotoxic to lymphocytes and Dalton's lymphoma cells at the same concentration. Cytotoxic effect was found within 30 min at room temperature (30°C). The active constituent was found to be "curcumin" which showed cytotoxicity to lymphocytes and Dalton's lymphoma cells at a concentration of 4 μ g/ml [30].

Antimalarial activity

Odugbemi *et al.* suggested in their review article the combinations of various herbal plants that have the potential to act against malarial parasites. The combination including *Curcuma longa* is (*Ocimum gratissimum* [leaves], *Anacardium occidentale* [foliage leaves], *Lecaniodiscus cupanioides* [foliage leaves], *Curcuma longa* [foliage leaves], *Citrus aurantifolia* [foliage leaves]) [31].

Anticoagulant activity

Hermann *et al.* stated that 1,7-Bis(4-hydroxy-3-methoxyphenyl)-1,6,7,5-dione (curcumin), *p,p'*-dihydroxydicinnamoylmethane, and *p*-hydroxycinnamoyl(feruloyl)methane were found to be the principles of *C. longa* with anticoagulative activity when recalcification time in male mice was measured [32].

Srivastava *et al.* stated that curcumin at doses between 25 and 100 mg/kg (i.p.) inhibits collagen and adrenaline-induced platelet aggregation in *in-vitro* as well as in *in-vivo* but does not affect prostacyclin synthesis by rat thoracic aorta [33].

C. PSEUDOMONTANA

C. pseudomontana J. Graham belongs to the family *Zingiberaceae*, commonly known as Hill Turmeric. *C. pseudomontana* has small root stock, bearing small almond-like or subglobose tubers at the ends of the fibers (but no sessile tubers) and it is edible. Leaves are uniformly green, reaching 2 ft or more long (including the petiole), 4–6' broad, lanceolate oblong acuminate, tapering to the base, petioles 8–15 in long [34]. *C. pseudomontana* is an extremely rare *Zingiberaceae* species found so far only in the Naikongchhari-forested area of Bandarban district in the southeastern hilly area of Bangladesh. In English, it is known as hill turmeric, while in Bangladesh, it is sometimes referred to as bon holud (wild turmeric) or pahariholid (hill turmeric) by the local people [35].

Pharmacological activity

Antimicrobial activity

All extracts of the rhizome of *C. pseudomontana* were screened *in vitro* for their antimicrobial activities against clinically isolated bacterial and fungal strains, such as *S. aureus*, *Salmonella typhi*, *E. coli*, and *Aspergillus terreus*. In result, it is found that methanolic extract showed 4 mm zone of inhibition against *S. typhi*, 6 mm against *S. aureus*, and 8 mm against *E. coli*. There were 2 mm zone of inhibition in acetone and 6 mm in methanol and aqueous against *A. terreus*. There was no zone of inhibition in chloroform against all the microorganisms and acetone as well as aqueous against *S. typhi*, *S. aureus*, and *E. coli*. Conducted by Begam *et al.*, *C. pseudomontana* was proven to be effective [36].

Antitubercular activity

Rhizome extract exhibited significant antitubercular activity against *M. tuberculosis* H37 RV conducted by Hiremath and Kaliwal [37].

Anticancer activity

Different plant extract of *C. pseudomontana* contains certain types of active compounds; these active compounds show anticancer activity. These active compounds are extracted with appropriate solvent (organic/inorganic). Selection of solvent depends on the type of active compound conducted by Bisht *et al.* [38].

C. XANTHORRHIZA

C. xanthorrhiza Roxb. commonly known as temulawak or Javanese turmeric is one type of herbs derived from family *Zingiberaceae*. Xanthorrhizol (XNT) is a bisabolane-type sesquiterpenoid compound extracted from *C. xanthorrhiza* Roxb. [39]. XNT is the most active and abundant compound isolated from the essential oil of the rhizomes of *C. xanthorrhiza* Roxb. [40]. It is used in Southeast Asian countries for food and medicinal purposes. *C. xanthorrhiza* has been traditionally used to treat stomach disease, liver disorder, constipation, dysentery, diarrhea, children's fever, and hemorrhoids [41]. Biological properties of the extracts and essential oils from *C. xanthorrhiza* have been studied by many researchers. They include hepatoprotective and antinociceptive activities [42]. The dried rhizomes of *C. xanthorrhiza* are grounded and soaked in 95% ethanol for 2 days at room temperature [43]. This plant originated from Indonesia, more specifically from Java island, of which it spreads to several places in the biogeographical region, Malaysia [44]. Rhizome of *C. xanthorrhiza* contains two characteristic constituent, i. e., curcuminoids (*curcumin* and *desmethoxycurcumin*) and XNT [45]. XNT is a bisabolane-type sesquiterpenoid compound. It has been well established to possess a variety of biological activities such as anticancer, antimicrobial, anti-inflammatory, antioxidant, antihyperglycemic, antihypertensive, antiplatelet, nephroprotective, hepatoprotective, estrogenic, and antiestrogenic effects [39]. Some studies suggest that *C. xanthorrhiza* also has the potential to cause herb-drug interaction with drugs that are primarily metabolized by UDP-glucuronosyl transferase and glutathione S-transferase enzymes [46].

Pharmacological activity

Cytotoxicity activity

The ethyl acetate fractions of samples *C. xanthorrhiza* exhibited the highest cytotoxic activities, and all samples in cytotoxic activities were showed not significantly with the others in $p \leq 0.05$. The cytotoxicity of the ethyl acetate fractions in different sample rhizomes of *C. xanthorrhiza* was evaluated using the brine shrimp lethality test for potency in preliminary screening for cytotoxins as anticancer [47].

Hepatoprotective activity

C. xanthorrhiza has been used for centuries in the traditional system of medicine to treat several diseases such as hepatitis, liver complaints, and diabetes. It has been consumed as food supplement and "jamu" as a remedy for hepatitis. Hence, it leads in research for the activity on the liver. Ismail *et al.* carried out the research on antioxidant activity of the standardized *C. xanthorrhiza* fractions using *in vitro* assays. Hepatoprotective assay was conducted against carbon tetrachloride-induced hepatic damage in rats at doses of 125, 250, and 500mg/kg of hexane fraction. Highest antioxidant activity was found in hexane fraction. In the case of hepatoprotective activity, *C. xanthorrhiza* hexane fraction showed significant improvement in terms of a biochemical liver function, antioxidative liver enzymes, and lipid peroxidation activity [48].

Anti-inflammatory activity (ulcerative colitis)

Chun *et al.* carried out the research on *C. xanthorrhiza*, and the findings suggest that *C. xanthorrhoea* is an effective inhibitor of DSS-induced ulcerative colitis in mice. The anti-inflammatory effects of *C. xanthorrhiza* were associated with attenuated tissue injury, recruitment of neutrophils, and suppression of inflammation-related gene expression. The researchers conclude that *C. xanthorrhiza* is a relatively edible and non-toxic natural plant material that appears to be a beneficial gut-related dietary supplement and that its use may provide an alternative approach to modulating inflammation [49].

Antimicrobial activity

XNT is considered active against a variety of pathogenic microorganisms. Antimicrobial effects of XNT included antibacterial [50-52]. XNT also strongly inhibited Gram-positive bacteria *S. aureus*, methicillin-resistant *S. aureus*, Gram-negative bacteria *E. coli* [53], and acne-causing bacteria *Propionibacterium acnes* [54].

C. ZEDOARIA

C. zedoaria Rosc. is a commonly available plant in the dava-bazaar as Kachore is a potential antimicrobial agent as it shows significant activity against common bacterial and fungal pathogen [55]. It also is very common ingredient of body deodorant (ubtans), hair oils, and face washes [56,57]. *C. zedoaria* is a traditionally used medicine which is described in ancient Ayurveda literature for ailments such as arthritis, colic, cough, asthma, diarrhea, dysentery, rheumatism, and skin disease [58,59]. According to the traditional Chinese medicine, *C. zedoaria* rhizomes contain several specific sesquiterpenes that are effective against flatulent colic, debility of the digestive organs, amenorrhea, hepatocirrhosis, cancer, oxidation, and human blood aggregation [60-65].

Pharmacological activity

Antitumor activity

The compound isolated from the rhizomes of *C. zedoaria*, characterized as isocurcumenol by the MS and IR spectra, significantly inhibited the cell proliferation in human lung, leukemia, nasopharyngeal carcinoma, and murine lymphoma cells.

The *in vivo* studies suggested the non-toxic nature of the compound at low doses and its antitumor effects in the ascetic tumor development comparable to the standard drug used to treat lymphoma and cyclophosphamide. The present study highlights the antitumor potential of isocurcumenol isolated from *C. zedoaria* to be exploited further to be developed as a good antitumor agent [66].

Antimicrobial and antibacterial activity

Ethanol extract of *C. zedoaria* was tested against various pathogenic bacteria and fungi. The results obtained are based on antibacterial and antifungal activity as shown by essential oil of *C. zedoaria* on various organisms. Ethanol extracts showed excellent activity against *S. aureus* and *Trichophyton mentagrophytes* [58].

Anticancer activity

In the previous study, a crude ethanolic extract of *C. zedoaria* showed an inhibitory effect against OVCAR-3 cells (human ovarian cancer) [60,67,68].

Anti-amoebic activity

Alcoholic extract of rhizome of *C. zedoaria* was able to inhibit the growth of *Endamoeba histolytic* at a concentration of 1-10 mg/ml [69].

Hepatoprotective activity

Hepatoprotective sesquiterpenes were isolated from the aqueous acetone extract of the rhizome of *C. zedoaria*. Principal sesquiterpenes, furanodiene, germacrone, curdione [70], neocurdione [71], curcumenol, isocurcumenol, aerugidiol, zedoarondiol, curcumenone, and curcumin were found to show the potent protective effect on D-galactosamine (D-GalN)/lipopolysaccharide-induced acute liver injury in mice [72].

Antivenom activity

Aqueous extract of *C. zedoaria* was investigated for inhibitory activity by binding of anticobra venom antibody to antigen of cobra venom using the 96-well plate enzyme-linked immunosorbent assay method. In this study, the extract was allowed to react with immobilized venom before the addition of antivenom antibody. The extract of *C. zedoaria* showed clear inhibitory activity. It was found that the extract targeted

neurotoxin and protein-degrading enzyme present in venom, thus suggesting the use of aqueous extract as antivenom [73].

CONCLUSION

Curcuma species are very promising medicinal plants with great pharmacological impact. The above review article gives an insight on the potential of different *Curcuma* species regarding their medicinal value. Various studies demonstrated that these *Curcuma* species possess anticancer, antimicrobial, antitubercular, antitumor, antibacterial, wound healing activity, and fungicidal. Review of the literature concluded that the curcuma species have great potential in innovative research in future and to be considered as a useful herbal medicinal plant.

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AUTHOURS' CONTRIBUTION

We declare that this work was done by the authors named in the article, and all liabilities pertaining to claims relating to the content of this article will be borne by the authors. Miss Farha Khan collected the data and analyzed the data. Dr (Mrs) Vanita Kanase proofread the whole manuscript and suggested the necessary changes and help in designing the manuscript.

CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this paper.

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