AN OVERVIEW OF MEDICINAL VALUE OF CURCUMA SPECIES

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INTRODUCTION

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 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 bilary 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, antibacterial, antitubercular, 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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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. cycloolefinolone, 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

Ashiti pati et al. in their present study evaluated the anti-inflammatory activity of C. aeruginosa ethanol extracts in experimental animals. The topical anti-inflammatory activity was analyzed using croton oil-induced ear edema. Topical application of (Curcuma aeruginosa ethanol 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 ethanol 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                                      |
|----------------------|---------------------------------------------------------------|
| *Curcuma aeruginosa* | Antimicrobial[5]                                              |
| *Curcuma amada*      | Anti-inflammatory[6]                                          |
|                      | Antioxidant[9]                                                |
|                      | Anti-inflammatory[8]                                          |
|                      | Antitubercular[10]                                            |
| *Curcuma aromatica*  | Anti-ulcerogenic[12]                                          |
| *Curcuma aromatolia* | Wound healing[14]                                             |
|                      | Anticancer [13,15-17]                                         |
|                      | Antioxidant [20,21]                                           |
| *Curcuma caesia*     | Larvicidal [1,3,18,19]                                         |
|                      | Smooth muscle relaxant[22]                                    |
| *Curcuma longa*      | Anticancer[30]                                                |
|                      | Antimalarial[31]                                              |
|                      | Anticoagulant[32,33]                                          |
| *Curcuma pseudomontana* | Antimicrobial[36]                              |
|                      | Antitubercular[37]                                            |
| *Curcuma xanthorrhiza* | Anticancer[38]                           |
|                      | Cytotoxicity activity[47]                                    |
|                      | Hepatoprotective[48]                                         |
| *Curcuma zedoaria*   | 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, hiccough, 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, enterokeinase inhibitory activity, central nervous system depressant, and analgesic activity. The major chemical components include starch, phenolic acids, volatile oils, curcuminoids, and terpenoids suchs 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**

Polegeoudra et al. stated that chloroform extract of mango ginger (*C. amada* Rosh.) 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 alabandene diterpenoid 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. ANGUJSTIFOLIA**

*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**

Rajashekhara 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 [13,10]. The ethanolic extract of *C. aromatica* showed a protective effect against *Armigeres subalbatus, Culex*.
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* function as anti-inflammatory, antivirus, and antioxidant agent [20]. The methanol extract of essential oil from the leaves exhibited remarkable superoxide radical scavenging activities [21].

### Pharmacological activity

#### Smooth muscle relaxant

*C. caesia* is widely used in India as both an anti-inflammatory and antistaminic 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, gibberlactamide, 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-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 activity [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%) is obtained by steam distillation of rhizomes which has *a*-phellandrene (1%), sabinene (0.6%), cineole (1%), borneol (0.5%), zingiberene (25%), and sesquiterpenes (5.3%) [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].

#### Anticoagulant activity

Hermann *et al.* stated that 1,7-Bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione (**curcumin**), p,p′-dihydroxydichloro-m-xylomethane, and p-hydroxyanisyl(or 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 vitro as well as 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 pahar holud (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* H37Rv conducted by Hiremath and Kailwar [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 hemmorhoids [41]. Biological properties of the extracts and essential oils from _C. xanthorrhiza_ have been studied by many researchers. They include hepatoprotective and antiinociceptive activities [42]. The dried rhizomes of _C. xanthorrhiza_ are ground 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 spread 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-inflammatotory, antioxidant, anti hyperglycemic, anti hypertensive, 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 ps<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 preiminary screening for cytostatins 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 various organisms. Ethanolic extracts showed excellent activity against _S. aureus_ and _Propionibacterium acnes_ [54].

Anti-inflammatotory 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-inflammatotory 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_

Ethanolic 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. Ethanolic 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) [60,67,66].

_Anti-amobic 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 aceton extract of the rhizome of _C. zedoaria_. Principal sesquiterpenes, furanodiene, germacrene, curdione [70], neocurdione [71], curcumene, isocurcumene, agerudigl, zedoarondiol, curcumene, and curcumen were found to show the potent protective effect on _D-galactosamine_ (D-GaIN)/lipopolysaccharide-induced acute liver injury in mice [72].

_Antivenom activity_

Aqueous extract of _C. zedoaria_ was investigated for inhibitory activity by binding of anticoobra 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, antitubercurial, 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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AUTHORS’ 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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