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Curcuma angustifolia Roxb, (Zingiberaceae): Ethnobotany, phytochemistry and pharmacology: A review

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Abstract
India has rich history of using many plants for medicinal purposes. Medicinal plants are playing very active role in traditional medicines for the treatment of various ailments. However a key obstacle, which has hindered the promotion in use of alternative medicines in the developed countries, is no evidence of documentation and absence of stringent quality control measures. There is a need for the record of all the research work carried out on traditional medicines in the form of documentation. As only little studies are done on this plant, the purpose of current review is to make accessible up-to-date information on morphology, therapeutic uses, phytochemistry and pharmacological activities on diverse parts of *Curcuma angustifolia* Roxb (*C. angustifolia*). This review was assembled using technical literature from electronic search engine such as Springerlink, BioMed Central, PubMed, Scopus, ScienceDirect, Scielo, Medline and Science domain. Supplementary texts were obtained from books, book chapters, dissertations, websites and other scientific publications. *C. angustifolia* (Zingiberaceae) is one of over 80 species belonging to the genus *Curcuma*. *C. angustifolia* is a fast growing annual rhizomatous herb. It is a perennial and a flowering plant, with modest and small spiked inflorescences of three or four yellow, funnel-shaped flowers within tufts of pink terminal bracts (coma bracts). In India it is commonly known as Tikur or Tavaksheeri. This species can also be found in Burma, Laos, Nepal, Pakistan and other parts of world. The major chemical constituents of the plants are methyl eugenol, camphor, cineol etc. Rhizome is the used as demulcent, nutritious, contains starch which is used for children due to easily digestible. It is an excellent diet in the form of conjee in case of dysentery, dysuria and gonorrhea etc. Medicinal uses of rhizome arise from the bioactive components. Bioactive components are responsible for antioxidative, anti-inflammatory properties, wound-healing, hypoglycemia, anticoagulant, antimicrobial activities. The plant is used in different traditional systems of medicine in the treatment of various diseases. The present paper enumerates the Pharmacognostic, morphological and ethnobotanical, pharmacological importance of the *C. angustifolia*, which may help the researchers to set their minds for approaching the utility, efficacy and potency of the plant.

Keywords: Medicinal plants, *Curcuma angustifolia* Roxb, Zingiberaceae, phytochemistry, pharmacological

Introduction
India perhaps the largest producer of medicinal herbs and is called Botanical Garden of the World. In India use of the different parts of several medicinal plants to cure specific ailments has been in vogue from ancient times. The indigenous system of medicine, namely, Ayurvedic, Siddha, and Unani, has been in existence for several centuries. Some drugs from Ayurveda approaches modern diseases, have already reached the market place [1]. In modern medicines, plants occupy a very important place as the raw material for some important drugs. Synthetic drugs are effective in controlling different diseases but these synthetic drugs are out of reach of millions of people. In earth, around 3.6 lakh species of medicinal plants are present, among these 1.4 lakh species are in India [2], in Sri Lanka around 1400 and in Nepal around 700 [3]. In the latest survey, it is estimated that around 70,000 plant species have been used for medicinal purposes. The herbs provide the starting material for the synthesis of conventional drugs. It was believed that medicinal plants were best medicines to treat illness and cure disease due to the presence of complex chemical constituents [4]. The genus *Curcuma*, locally called haldhi, a perennial rhizomatous flowering plant belonging to family Zingiberaceae native to tropical and subtropical regions. The name *Curcuma* is derived from the Arabic word kurkum, meaning "yellow," which refers to the color of the rhizome. *Curcuma* is extensively cultivated in tropical and subtropical regions of Asia, Australia and South America [5]. There are approximately 93-100 accepted *Curcuma* species, however the exact number of species is still controversial, some of which have been used in traditional systems of medicine

(Ayurveda, Siddha, Unani) for a long time [6]. The genus is best known for being an essential source of coloring and flavoring agents in the Asian cuisines, traditional medicines, spices, dyes, perfumes, cosmetics and ornamental plants [7]. Several *Curcuma* species are used medicinally in Bangladesh, Malaysia, India, Nepal and Thailand [8] for treating pneumonia, bronchial complaints, leucorrhea, diarrhea, dysentery, infectious wounds or abscesses and insect bites [6, 8, 9]. The rhizome is the most commonly used part of the plant. The main active components of the rhizome are the nonvolatile curcuminoids and the volatile oil [10-12]. Curcuminoids (curcumin, demethoxycurcumin and bisdemethoxycurcumin) are nontoxic polyphenolic derivatives of curcumin that exert a wide range of biological activities [13]. Several phytochemical studies on *Curcuma* oils led to the identification of sesquiterpenoids and monoterpenoids as the major components [13]. The essential oil of *Curcuma* species possesses a wide variety of pharmacological properties, including anti-inflammatory, anticancerous, antiproliferative, hypocholesterolemic, antidiabetic, antihepatotoxic, antidiarrheal, carminative, diuretic, antirheumatic, hypotensive, antioxidant, antimicrobial, antiviral, insecticidal, larvicidal, antivenomous, antithrombotic, antityrosinase, and cyclooxygenase-1 inhibitory activities, among others [11,14-21]. *Curcuma* oils are also known to enhance immune function, promote blood circulation, accelerate toxin elimination and stimulate digestion [22, 23]. *C. longa* (turmeric) and C. *zedoaria* (zedoary) are the most extensively studied species of *Curcuma* due to their high commercial value. Other *Curcuma* species such as *C. angustifolia, C. caesia, C. rubescens, C. amada, C. leucorrhiza, C. montana, C. aromatica, C. pseudomontana, C. caulina, C. mangga, C. phaeocaulis, C. pierreana, C. purpurascens C. zanthorrhiza* etc. have been studied to a lesser degree [24]. *C. angustifolia* Roxb (Zingiberaceae), commonly known as East Indian Arrowroot is widely distributed throughout central, southern and eastern India [25, 26]. It is a perennial flowering plant, with modest and small spiked inflorescences of three or four yellow, funnel shaped flowers within tufts of pink terminal bracts. It is processed by cutting, peeling, rubbing fresh rhizome bulbs on rough surface of stone or on sieves of rough surface, soaking with water, decanting and drying [27]. The rhizomes of the plant contain mostly carbohydrates, which are processed to obtain the commercial starch called 'tikhur'. This starch is recommended as a dietary aid for gastrointestinal disorders. It is used as a diuretic and in the treatment of chronic ailments colitis, diarrhea, dysentery and peptic ulcers because of its soothing effect [28]. It also can be used as an ingredient in cakes, fruit preserves, biscuits and puddings. The Taxonomy of *C. angustifolia* consists of Kingdom: Plantae, Class: Liliopsida, Subclass: Commelinidae Order: Zingiberales, Suborder: Zingiberanae, Family: Zingiberaceae, Genus: *Curcuma* L, Species: angustifolia. The vernacular names of the plant is (Sanskrit)-Tavakshira, tavaksheera, payaksheera, tavakshiri, vamsalocana, (Hindi)-Tekhur, tikhur, theksura, thavsasheera, thikora, thavakheera, (English)-East Indian arrow root, *Curcuma* starch (Kannada)-Kaadu arrow root, kovegida, kove hitting gida, thavakeela, (Telugu)-Gaddalu, (Tamil)- Kisangu, araukizhangu, kooa, artimavu, kookai, kua, (Malayalam)-Koova, kuva-kizhanna, (Tulu)- Koove, (Konkani)-Koovyajhaad,(Marathi)-Tavakira, thavakheera, thavakil, (Gujarat)-Tavkhir, tikhur, (Bengali) - Tikkur, keturihalodhi [29, 30].

Research methodology

To recognize pertinent information on the botany, medicinal uses, phytochemistry and biological activities of *C. angustifolia*, a review was compiled based on scientific literature from various sources including Google Scholar, Web of Science, Sci Finder, Scopus, Science Direct, Pub Med, Scielo, Springerlink, Google Patents, Espacenet, BioMed Central (BMC) and Medline. The keywords used for recognition of relevant data included dissimilar scientific name and synonyms, common English names and the terms: biological activities, medicinal uses, ethnobotany, ethnopharmacology, medicinal, pharmacology, phytochemistry and therapeutic value, *C. angustifolia*, Tekhur, East Indian arrow root. Further literatures were obtained from books, book chapters, theses, websites and conference proceedings.

Distribution and Cultivation

It distributed throughout central, southern and eastern India but most commonly reported from the Northeast and Western Coastal Plains and hills of India [25, 26]. The plant occurs as a wild growth in hilly tracts of Maharashtra, Madhya Pradesh, Andhra Pradesh, Himachal Pradesh, Odisha, Chhattisgarh, Central Himalayas, Karnataka, Bihar, West Bengal, Tamil Nadu, and Kerala. It is cultivated and common in other countries such as Sri Lanka, Burma, Laos, Nepal, Pakistan Asia, Africa, Cambodia, North Australia and China [31-33]. It requires temperatures at or above 1 °C (34 °F). It prefers shady areas at altitutes of 450m and grows best in moist soil that is sandy, pebbly or loamy. *C. angustifolia* is often found at the edges or in the clearings of forests. Planted in late autumn and watered occasionally during the dry period [34].

Morphology

C. angustifolia is a rhizomatous, slender branched herb grows 90-180 cm in height with fleshy cylindrical rhizome and small rootstock.

Stems: Stems usually short, replaced by pseudo stems formed by leaf sheaths.

Leaves: Leaves are typically simple, distichous, green, glabrous and lanceolate with margins that are entire. They appear in an opposite arrangement and are deciduous. They display fine parallel venation off of a central midrib. The upper surface of the leaves is usually a darker shade of green than the lower surfaces. Leaves may grow to about 36-37 cm (14-15 in) length and 8-10 cm (3.1-3.9 in) in width. The leaves also smell and taste similar to turmeric [35].

Flowers: It is a perennial and a flowering plant, bisexual, epigenous, zygomorphic with modest and small spiked inflorescences of three or four yellow, funnel-shaped flowers within tufts of pink terminal bracts. The bracts are boat-shaped and encase the entire perianth of the flower. As is common to the genus, the flowers of C. angustifolia have double anthers, a slender style and a globular stigma. Flowers are usually seen at the beginning of the monsoon (rainy) season from July to August, before the leaves have had the chance to fully develop and they continue to flower even after the leaves have fully developed. The calyx of the flower is usually 1 cm (0.39 in) long and very hairy, tubular, thin, split on 1 side, sometimes and spathe like, Apex 3-toothed or lobed that may appear to be triangular or obtuse. The corolla is white, and usually grows to be about 1.5–2 cm (0.59–0.79 in)

long that are also hairy, proximally tubular, distally 3- lobed; lobes varying in size and shape, Stamens or staminodes, into whorls. Lateral 2 staminodes of outer whorl petaloid, or forming small teeth at base of labellum, Ovary inferior, 3-loculed initially, 1- or 3-loculed when mature; ovules ± numerous perlocule [31, 34].

Fruit: capsule, fleshy or dry, dehiscent or indehiscent, sometimes berrylike.

Seed: a reddish-brown color, small, arillate.

Rhizome: C. angustifolia is its strong rhizome, which can grow to be up to 1.5 m (4.9 ft) in length. The rhizome of this plant is the primary source of its nutritive and medicinal properties [36].

Phytochemical constituents

Rhizomes of *C. angustifolia* have been found to contain secondary metabolites such as alkaloids, flavonoids, terpenoids, phenols, tannins, saponins, curcumin, steroids, glycosides, and oils [24]. It also contains starch, glucose, sugar, sesquiterpenoids, curcuminoids (curcumin, demethoxycurcumin and bisdemethoxycurcumin), curcumol, zederone, fyranodiene, pyrocurzerenone, procurcumenol, *Curcuma*nolide A&B, gum and fat [37, 38]. Rhizome oil contain ar-curcumine, β-pinene, α-terpineol, camphor, zingiberol, borneol [39], curzerenone [40], furanodienone, isofuranodienone [40], xanthorrhizol isomer, methyl eugenol, palmitic acid, germacrone, isoborneol, curdione, 1,8-cineole [25, 42, 43]. The GC-MS analysis of the young rhizome showed the presence of major compound like α-amorphene, camphor, 2,7-napthalenediol, trans-nerolidol, octadecanoic acid, butyl ester, humulen-6,7-epoxide [44]. Leaf oil contain curzerenone (33.2%), 14-hydroxy-δ-cadinene (18.6%) and γ-eudesmol acetate (7.3%) [45]. Root contains β-Elemenone, D-cymarose, B-D-glucosy 1-Lthebetose, cinnamic acid & acetic acid [43]. Stem contains glycosides tenacissosidas A-E, feronic acid, polyoxytregnanes, marstenacigenins A&B dresgenin. Seeds contain drebogenin, polyhydroxy, pregnanecissogenin, tenasogenin [36].

Edible property/ use as food

This species of plant has nutritional value as a source of starch for Indian foods. The rhizomes of *C. angustifolia* are typically ground into flour which can then be mixed together with milk or water to form a nutritious meal [31]. Tubers yield starch, which resembles arrowroot; it is easily digestible and highly nutritious recommended for infants, weak children and invalids. 10 gm rhizome powder is added with glass of milk and sugar candy and consumed as health drink to improve physical strength and improve potency [46]. A drink including C. angustifolia as an ingredient is also used as a replacement of breast-milk or as a nutritional supplement for babies a short while after weaning. The tikhur powder can be consumed by individuals during fast as (Upwash) it is rich in energy. It is found as a primary ingredient in cakes, fruit preserves, biscuits and pudding [35].

Medicinal uses

1. Root powder used with milk to treat burning micturition or urination, difficulty in micturition, fever, acidity, gastric reflux disorder, treat diarrhea to take with hot water and with honey to treat cough, dyspnea [47].
2. As per Ayurveda its is used as improve strength and immunity, aphrodisiac, improves vigor, nourishing, coolent, blood/skin/ bleeding disorders, jaundice, excessive thirst, liver diseases, asthma, TB, wt. loss, anemia [47].
3. Tuber powder used as reducing intestinal inflammation, carminative, astringent, dysentery, flatulence, cardiotonic [37].
4. Root stock is used as tonic. It is useful in leprosy, burning sensation, dyspepsia, asthema, jaundice, anemia, leucoderma, stones in kidney and disease of blood [48]. Rhizome is used in intestinal diseases, peptic ulcers, colitis, demulscent, bone fracture and swelling of body [49, 50].
5. The essential oil extracted from different parts of this species is used for antifungal and antibacterial activities [35], antimycotic activity [51] antioxidant activity [45].
6. C. angustifolia have been reported to be a rich source of proteins and carbohydrates and are used in culinary preparations as vegetables and food appetizers [24].

Scientists have extracted the starches within the flour produced by the ground rhizomes of *C. angustifolia* and compared it to corn starch. Its binding and disintegration properties make it a viable, and perhaps superior, substitute for cornstarch as an excipient in medicinal tablets [52].

Reported pharmacological activities of *C. angustifolia* Roxb

Antioxidant activity

Nahak and Sahu (2011) compared the antioxidant activity of five *Curcuma* species namely *C. longa*, *C. zedoaria*, *C. angustifolia*, *C. aromatica* and *C. amada* based on their curcumin and phenol content in DPPH radical model. *C. longa* exhibited the highest antioxidant activity 74.61±0.02% at IC50 value 24µg/ml followed by *C. zedoaria* (63.27±0.06%), *C. angustifolia* (58.35±0.06%), *C. aromatica* (55.38±0.06%) and *C. amada* (52.61±0.02%). Antioxidant activity in four species except *C. angustifolia* has strong correlation with curcumin and phenol content. However *C. angustifolia* may be active due to high aromatic oil content like eugenol, palmitic and camphor etc [32].

Jena *et al*. (2017) characterized essential oil extracted from rhizome and leaf of *C. angustifolia* by gas chromatography-mass spectrometry (GC-MS). The GC-MS analysis revealed the presence of 32 and 35 identified constituents, comprising 92.6% and 92% of total leaf and rhizome oil respectively. Antioxidant capacities of oil were assessed by various methods, (DPPH), (ABTS) and reducing power ability (RPA). The leaf oil showed more antioxidant potential as compared to rhizome oil and reference standards [45].

Dhal *et al*., (2012) compared the efficacy for antioxidant activity of both the crude (non-enzymatic) and enzymatic extracts of three important medicinal plants *C. zedoaria*, *C.caesia* and *C. angustifolia* respectively. Both the enzymatic and crude extracts of the rhizome and leaves of these plants have been analyzed for their free radical-scavenging activity in different in vitro systems, e.g. DPPH radical scavenging activity, hydroxyl radical-scavenging activity and different antioxidant enzymatic assay. The non-enzymatic extracts prove to be a better scavenger of free radical in comparison to enzymatic extracts in all the three *Curcuma* species [53].

Thapa and Basistha (2014) evaluated antioxidant *activity* hot and cold methanol extract *of C. angustifolia* against DPPH assay. Hot and cold methanol extract of the dried powder of

the rhizome of *C.angustifolia* was used as sample for antioxidant profiling which was compared with two standards namely BHT and Ascorbic acid. Further the percentage scavenging activity and the IC_{50} value was calculated [54].

Antioxidant and anti-proliferative activity

Assumi *et al*., (2017) evaluated antioxidant activity and anti-proliferative activity of aqueous extracts of budding flowers, leaves, full bloomed flowers and mixture of all parts of *C. angustifolia* by using DPPH assay, MDCK, Vero and HeLa cell lines. The inhibitory activity in all the three cell lines was found to be dose dependent. The result showed potential anti-proliferative and antioxidant properties that substantiate the belief of the indigenous people to include the plant in their dietary habits which could be exploited for use in preparation of herbal drugs and supplements [55].

Antioxidant, antimicrobial and anticancerous activity

Nayak *et al*., (2013) investigated the in vitro antioxidant, antimicrobial and anticancerous activity of *C. angustifolia* methanolic extracts a plant associate from Eastern Ghats of Odisha, India. Antioxidant activity of methanolic rhizome extract was evaluated in terms of total phenol content, ascorbic acid total flavonoids content, DPPH radical scavenging activity. Antimicrobial activity of plant extract was determined by agar well diffusion method against six bacterial strains including gram positive and gram negative bacteria. Cytotoxicity activity of plant extract was studied on cervical cancer cell line by MTT assay methods. Methanolic rhizome extract of *C. angustifolia* showed potential antioxidant, antimicrobial and anticancerous properties which could be exploited in preparation of herbal drugs with modern standard and safety [56].

Antimicrobial activity

Jadhao AS, Bhuktar AS (2017) evaluated antibacterial properties of methanolic extract of *C. angustifolia* rhizomes against P. aeruginosa, S. typhi, E. coli, S. arueus and S. flexneri by 96 well-plate method. The antibacterial activity may due to variety of secondary metabolites present in the plant, such as glycoside, flavonoid, tannin and phytosterol [57].

Panda *et al*., (2012) evaluated antibacterial activity of aqueous and methanol extracts of 72 plants using agar well diffusion (sample concentration of 100 mg/ml) against eight pathogenic bacteria responsible for diarrheal diseases. The results indicated that out of 77 plants species, 47 species exhibited antibacterial activity against one or more test organisms. Out of 168 extracts, 54 methanolic and 43 aqueous extracts expressed antibacterial properties. Salmonella typhi, Escherichia coli and Vibrio cholera were the most sensitive strain. Shigella dysentriae showed least activity compared to all other test strains [58].

Dubey and Sao (2018) Investigated stem extracts of *C. longa, Z. officinale, C. angustifolia* and *A. barbedensis* against skin pathogenic organisms like S. aureus, E. faecalis, P. saruginosa and C. albicans. The ethyl acetate from all the selected extracts has shown good activity with C. albicans. All the plant extracts have not shown antibacterial activity with the tested microbes at 20µl against skin disease causing microbes. The aqueous extracts of *A. barbedensis* and *C. angustifolia* have shown better antibacterial and antifungal activities at 50µl against skin disease causing microbes [59].

Viji and Wilson (2017) Investigated antimicrobial activity of silver nanoparticle, methanolic, ethyl acetate, chloroform rhizome extract of *C. angustifolia* against S. aureus, E. coli, K. pneumonia, B. subtilis, P. mirabilis, A. niger, M. indicus and R. stolonifer. Cytotoxic potential of the plant extracts and the nanoparticles was confirmed by brine shrimp lethality assay. Biological synthesis of silver nanoparticles was carried out from aqueous rhizome extracts of *C. angustifolia* by a microwave assisted approach. Antimicrobial efficacy against all the tested bacterial and fungal strains was confirmed. This green chemistry approach toward the synthesis of silver nanoparticles has many advantages in being an ecofriendly and less time consuming protocol [60].

Anti-ulcerogenic

Rajashekhara *et al*., 2014 evaluated the acute toxicity potential of the *C. angustifolia* and *M. arundinacea* along with their assessment for adaptogenic activity against forced swimming-induced hypothermia and gastric ulceration in rats. The adaptogenic and anti-ulcer activities were assessed by determining and comparing the changes in rectal temperature, ponderal changes, ulcer index and histopathological parameters in the test drug group with that of stress control group. Both the drugs did not produce any toxic symptoms or mortality even up to the maximum dose level of 4400 mg/kg. Both the test drugs significantly reversed the stress-induced gastric ulceration in comparison to stress-control rats [61].

Rajashekhara *et al*., 2014 compared the anti-ulcerogenic activity of rhizomes of *C. angustifolia* and *M. arundinacea* in pyloric ligation induced gastric ulcer in albino rats. The collected gastric contents were used for biochemical estimation and ulcer index was calculated from excised stomach. Both the test drugs showed statistically significant decrease in the volume, increase in the pH, reduced the free acidity of gastric juice and decreased the peptic activity. Both the test drugs proved anti-ulcer activity and prevents the chance of gastric ulcer [62].

Rajashekhara and Sharma (2010) evaluated the efficacy of Tugaksheeree on 67 patients of Amlapitta. A total of 84 patients suffering from Amlapitta were selected from the O.P.D. and I.P.D. sections in the department of Dravyaguna, I.P.G.T. and R.A., Hospital, Jamnagar, and were randomly divided into two groups. The efficacy of drug Tugaksheeree was studied through internal administration of the starches of *C. angustifolia* in Group I and *M. arundinacea* in Group II with the dose of 4 g TID with water for 30 days. Both the drugs were found highly effective in treating Amlapitta. They significantly relieved the cardinal symptoms viz., Avipaka, Tikta-amlodgara, Daha, Shoola, Chhardi and the associated symptoms viz., Aruchi, Gaurava, Udaradhmana, Antrakujana, Vit bheda, Shiroruja, Angasada, and Trit [63].

Antidiabetic activity

Sheikh *et al*., (2015) identified 15 medicinal plant species traditionally used as remedies to control diabetes. The methanolic extracts were screened for their α-glucosidase inhibitory activity. Hypoglycemic activity was assessed following glucose, sucrose and starch tolerance test on normal and STZ induced diabetic rats. The present study supports the traditional use of some of these medicinal plants in anti-diabetic remedies. The present study contributes to evidence for use of traditional medicine [64].

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