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CURCUMA AROMATICA SALISB: A MULTIFACETED SPICE

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ABSTRACT

Curcuma 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, germacrone as its major components. Extensive literature survey showed that the plant has anticancerous, anti-obesity,anti-acne, antitussive, antioxidant, anti-inflammatory, antidiabetic and wound healing properties. The rhizome extract of the plant is highly effective against many human pathogens as well as microorganisms causing food spoilage and food borne diseases. The plant thus proves to be a promising candidate for the development and designing of modern drugs for several diseases. The present study was aimed to review the phytochemical and pharmacological properties of *C. aromatica* Salisb.

Keywords: *Curcuma aromatica*, Rhizome extract, Pharmacological, Antimicrobial, Anticancerous.

INTRODUCTION

Curcuma aromatica Salisb., the wild turmeric, belonging to the family Zingiberaceae, is a threatened aromatic medicinal plant, well known for its multifaceted properties. It is mentioned as '*Vanaharidra*' in Ayurveda. The medicinal properties of this plant are being used in many traditional systems of medicines like Ayurveda and Unani. It is also one of the ingredients of many herbal medicines used in China and other South East Asian countries. Knowledge about the plants that has been used in traditional systems of medicine is helpful for the development of modern medicines by scientific approaches. Investigation of bioactive compounds in such plants is a novel area in pharmacological research. The use of this plant for many purposes has become more significant in the light of many scientific literatures published in the past decade showing its multifaceted properties.

Description and distribution

C. aromatica Salisb. is widely found in South Asian regions. It is found to be distributed from China southwards to Srilanka [1]. In India, it is seen in Himalaya region and Western Ghats. It is cultivated in some southern parts of India along with turmeric (*Curcuma longa* L.). The plant is an erect, perennial, rhizomatous herb propagated by rhizomes. The aboveground appearance of the plant is more similar to *C. longa* but the rhizomes are less pigmented with characteristic camphoraceous smell. The inflorescence comes out first from the dormant underground rhizomes in early spring. The broad and elliptic leaves which can grow 3-4 ft in height appear later. The plant shows fast and vigorous growth during monsoon season. The foliage dries up by late autumn and the rhizomes remains dormant during winter. The rhizomes have characteristic fragrance on attaining maturity. Flowers are white and pink toned with an orange lip and are borne on peduncles with crown of bracts. It does not set seeds usually. Improper cultivation practices, habitat destruction, deforestation, and the high demand of pharmaceutical industries on wild sources make this plant most threatened in many South Asian countries [2]. Since there are a number of constraints for the commercial cultivation of the plant, micropropagation protocol has been optimized for the large scale production to meet industrial demand for the rhizome and also for conservation [3].

Medicinal uses

The medicinal property of *C. aromatica* is well known since time immemorial. Apart from the antibacterial and antifungal activities, it is well known for its cosmetic use in India. The paste of rhizome is used for facial application to reduce acne and excessive hair growth and also to improve skin tone and complexion. It is

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traditionally used for gastrointestinal ailments, skin infections, arthritic pain and insect bites. The use of rhizome extracts as ingredients in many medicines by indigenous people are now being explored in phytopharmaceutical researches. The bioactive compounds of the plant have been proved for their anticancerous, anti-obesity, anti-acne, antioxidant, anti-inflammatory, anti-allergic, antidiabetic and wound healing potentials. It is also used in native perfumeries.

Chemical composition

The aromatic oils are well known for their antiseptic and medicinal properties and their fragrance. They are used in embalmment, preservation of foods and as antimicrobial, analgesic, sedative, anti-inflammatory and locally anesthetic remedies [4]. The rhizome is rich in a wide variety of secondary metabolites like alkaloids, flavonoids, tannins and terpenoids. In the plants from northeast India, the major constituents of the leaf oil were found to be camphor, ar-turmerone, curzerenone, 1,8-cineole and α-turmerone and rhizome oil consisted mainly of camphor, curzerenone, α-turmerone, ar-turmerone and 1, 8-cineole [5]. Apart from the above compounds like curzerenone, isoborneol and camphene are found in rhizome. The constituents like limonene in the leaf oil, caryophyllene oxide, patchouli alcohol and elsholtzia ketone in the petiole oil were also reported [6]. The petroleum ether extract from the rhizomes of *C. aromatica* from Vietnam yielded six oxygenated sesquiterpenes furanodiene, furanodienone, curzerenone, germacrone, curcumenone and zederone together with three sesquiterpene hydrocarbons α-humulene, β-selinene, α-selinene by flash chromatography on silica gel [7]. The rhizome extracts are also reported to contain curdione, neocurdione, curcumol, tetramethyl pyrazine, 1, 2-hexadecanediol [8]. Zederone, a sesquiterpene ketodioxide was reported by Neerja et al., [9]. Significant difference in the composition of phytochemicals has also been reported within the species [10]. The volatile oil mainly composed of β-curcumene, ar-curcumene, xanthorrhizol, germacrone, camphor, curzerenone, 7-methanoazulene, 1,8-cineole, β-elemene and linalool [11-14] and curcumin [15]. The rhizome extract contain p-cymene 2-oxabicyclo (3.2.1) octane 1,4-dimethyl-8-methylene, p-cymen-8-ol, bicyclo(2.2.1) heptane-1-acetyl-7-methylene, α-pinene and L-carveol [16]. *C. aromatica* oil extracted from rhizome contains a different spectrum of components related to sesquiterpenoids rather than curcuminoids [17]. Phytochemical investigation of the chloroform extract of the rhizomes of *C. aromatica* yielded three new phytoconstituents characterized as n-heneitriacontan-14-one; *n*-pentatriacontan-5-one; 11α-cyclopentyl-*n*-decan-1-ol (curcumapentadecanol) along with the known compounds stigmasterol and *n*-nonacosan-1-ol [18]. Variations in the constitution of essential oil were noted among the extracts of rhizome from different locations. The comparative study of essential oil constituents of the rhizome from India and Japan revealed that oil from Japan contain curdione, germacrone, 1,8-cineole, (45,5S)-germacrone-4,5-epoxide, β-elemene, and linalool as major constituents, whereas those in the oil from India were β-curcumene, ar-curcumene, xanthorrhizol, germacrone, camphor, and curzerenone [11]. The main components in the rhizome from Guangxi were eucalyptol, neocurdione, linalool, camphor, α-terpineol and germacrone [19]. Neerja and Himanshu [20] reported β-sitosterol-3-O- β-d-glucopyranoside for the first time from the ethyl acetate extract of rhizomes. Feng et al. [21] reported curdione as the major component in the rhizome of different growth periods. Analysis of the hexane extract by Revathi and Malathy [22] revealed the presence of 13 compounds. The major component was germacron (40.46%) followed by à-vatirenene with 34.73% and androstan-17-one, 3-ethyl-3-hydroxy-(5à) with 13.42%.

Pharmacological activities

Antioxidant activities

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, anti-virus, and anti-oxidation agent [17]. The methanol extract of essential oil from the leaves exhibited remarkable superoxide radical-scavenging activities [14]. The oil and extracts of *C. aromatica* thus could serve as an important bio-resource of antioxidants for use in food industries. Tsai et al. [23] reported high scavenging abilities of *C. aromatica* rhizome on 1, 1-diphenyl-2-picrylhydrazyl (DPPH) by ethanolic and hot water extracts. Toluene extract of *C. aromatica* exhibited significant antioxidant activities both *in vitro* and *in vivo* [24]. The ethanol extracts of *C. aromatica* from India, which had high total polyphenol content and strong radical scavenging activities, exhibited relatively high Acetylcholinesterase (AChE) inhibitory activity similar to that of *C. longa*. from Myanmar [25]. Ethyl acetate and dichloromethane extracts is reported to have high antioxidant activity [26].

Anticancerous activities

Curcumin, a potential antioxidant extracted from *C. aromatica* has been widely studied and showed anti-carcinogenic properties in a wide variety of cell lines [27-29]. *C. aromatica* has been reported to exert various medicinal activities such as promoting blood circulation to remove blood stasis and for the treatment of cancer [30]. The infusion of oil *via* the hepatic artery has been proven to exert ideal therapeutic effects in humans with primary liver cancer and rats with transplanted hepatoma [31]. Curcumin and its analogues from the rhizomes (CA-2, 3 and 4), at the non-cytotoxic concentration of 10μM, inhibited the invasive ability of colon 26-L5 cells. Among these curcuminoids, CA-4 showed the strongest activities, inhibiting both tumor cell invasion and migration in a concentration-dependent manner [32]. The ethanolic extract has potent antiangiogenic and pro-apoptotic properties under *in vivo* conditions that can be developed into a potential anticancer drug [33]. Decreased incidences of intestinal metaplasia and esophagoduodenal anastomosis (EDA) were observed in the EDA rats with *C. aromatica* oil treatment [34]. Polyxylose from hot water-

soluble crude polysaccharide extract from the rhizomes can significantly inhibit gingival fibroblast cells proliferation by 92 % [35]. Curdione, one of the major constituent, plays an important role in the CYP3A4 inhibitory activity of *C. aromatica* and the activity might be by accelerating the degradation of CYP3A4 [36]. Curcumin from *C. aromatica* can induce apoptosis by modulation of bax/bcl-2 in SMMC-7721 cells and hence can acts as an anticancer agent for human hepatomas [37]. β-elemene, a sesquiterpene from rhizome is reported to have the ability to inhibit proliferation and induce apoptosis in hepatoma HepG2 cells. The apoptosis induction is related with up-regulating of Fas/FasL expression [38]. A combination of curcumin from *C. aromatica* and resveratrol from *Polygonum cuspidatum* is a promising novel anticancer strategy for liver cancer. It elicited a synergistic antiproliferative effect and upregulated intracellular reactive oxygen species (ROS) levels in Hepa1-6 cells [39]. Germacrone, one of the major bioactive components of the *C. aromatica* extracts, can inhibit the proliferation of human glioma cells via regulating the expression of proteins associated with apoptosis and G1 cell cycle arrest [40]. Zhao et al.[41] reported *C. aromatica* oil as an effective anti-fibrosis medicine especially in early renal fibrosis stage. It also could lower levels of lipid, acetoacetate, glucose, phosphorylcholine/choline, trimethylamine oxide and raise levels of pyruvate and glycine in the serum of the rats. Hence administration of the oil can ameliorate renal fibrosis symptoms by inhibiting some metabolic pathways, including lipids metabolism, glycolysis and methylamine metabolism.

Larvicidal property

The rhizome extract and its volatile components of the plant are reported for their antilarvicidal activity. Das et al.[42] 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. 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 *Aedis togoi* [43]. The volatile oil also possesses insecticidal activity against white termite (*Odontotermes obesus* Rhamb.) from sugarcane fields [16]. Choochote et al. [13] evaluated antimosquito potential of rhizome extract and volatile oil of *C. aromatica* and reported significantly high larvicidal activity against the 4th instar larvae of *Aedis aegypti.* Two guanine type bioactive sesquiterpene compounds, namely 9-oxoneoprocurcumenol and neoprocurcumenol were reported to be responsible for the larivicidal activity of the rhizome extracts against *Culex quinquefasciatus*. Among the two compounds, neoprocurcumenol exhibited least efficacy [44].

Antimicrobial activity

The plant has been using against different type of skin infections since time immemorial. It is well known for its antimicrobial activity against several plant as well as human pathogens. Aqueous extracts of rhizomes exhibited better antibacterial activity as compared to their petroleum ether, methanolic and ethanolic extracts against pathogens like *Bacillus subtilis, Staphylococcus aureus, S. epidermis, Escherichia coli, S. flexineria and Psuedomonas aeruginosa* [45]. The extracts of hexane, chloroform, ethyl acetate, methanol and petroleum ether of *C. aromatica* displayed remarkable antibacterial activity against *S. aureus, Listeria monocytogenes, B. subtilis, P. aeruginosa, Salmonella typhimurium* and *E. coli.* Hence *C. aromatica* can be used as a natural preservative in food against the well-known causal agents of food borne diseases and food spoilage [14]. The *in vitro* investigations of the oil proved it to be an effective anti-dermatophytic agent. It is effective against three common dermatophytic fungi *viz, Epidermophyton floccosum, Microsporum gypseum* and *Trichophyton rubrum* causing ringworm infection in human beings [46]. It also showed quick killing activity, broad fungicidal spectrum, long shelf life, and an edge over some synthetic antifungal compounds. The rhizome extract of *C. aromatica* is effective against various multiresistant urinary tract infection pathogens *P. aeruginosa,* Methicillin resistant *S. aureus* (MRSA), Vancomycin resistant *Enterococcus faecalis* (VRE) and *E.coli* [47]. *C.aromatica* oils also produced high inhibitory activity against *S. aureus, B. subtilis* and *E. coli* bacteria [48]. It also showed potential antimicrobial properties against several human pathogenic bacteria including *B. subtilis, S. aureus, P. aeruginosa, Shigella sonnei,* and *S. dysenteriae* [3]. The volatile oil showed antifungal activity against plant pathogens like *Colletotrichum falcatum, Aspergillus terreus, A. niger, Fusarium moniliforme* and *Curvularia palliscens* [16]. The hexane extract of the rhizome showed bactericidal activity against *S. aureus, Streptococcus sp., Enterococcus faecalis* [22]. Ethyl acetate extract of rhizomes of *C. aromatica* was also reported to be effective against three plant pathogenic fungi *viz. Rhizopus stolonifer, Botrytis cinerea* and *Colletotrichum coccodes* [49]. Hexane, dichloromethane and ethyl acetate extracts of rhizomes are reported to have activity against *S. aureus, P. aeruginosa* and *E. coli* [26].

Other properties

The rhizome extract of the plant is reported to have several other potentials other than the properties mentioned above. Widespread studies are being carried out worldwide to exploit the complete potentials of the plant against many diseases. The alcoholic extract of rhizomes has moderate antihelmintic activity against human parasite *Ascaris lumbricoides* [50]. Ethanolic extract of rhizomes of *C. aromatica* was reported for its antitussive effect on sulfur dioxide induced cough model in mice [51]. The ethanolic extract of *C. aromatica* and its formulations has significant anti-inflammatory and wound healing activity in arachidonic acid - induced ear inflammation. It also has significant effects in excision wound model in albino mice [52]. *C. aromatica* leaf extract has a potential to modulate the renal dysfunctioning caused by arsenic trioxide. It restored the increased serum levels of urea, uric acid and

creatinine to normal on nephrotoxicity induced by arsenic trioxide in albino rats [53]. The ethanolic extracts of *C. aromatica* exhibited significant antiinflammatory activity against the carrageenan-induced rat paw edema [54]. Toluene extracts of *C. aromatica* was found to be effective as antidiabetic both *in vivo* and *in vitro* and hence is potential to be used as an alternative herbal medicine in the treatment of diabetes [24]. Inhibition of hyperlipidemic atherosclerosis by *C. aromatica* was associated with a decrease in plasma lipids and an increase in antioxidative abilities was reported in Triton X-100 induced hyperlipidemic rat model [55]. The extract of rhizome was effective against snake-venom of Cobra (*Naja kaouthia* and *Ophiophagus hannah*) and Viper (*Daboia russelli* and *Echis carinatus*) venom both *in vivo* and *in vitro* [56].

CONCLUSION

C. aromatica is one of the most useful plants with highly potent pharmacological activities. These properties are being used by the people in countries like India, China and other South East Asian countries. Many reports of its anti-cancerous activity show its potential to be used as an effective anti-cancerous agent. The antimicrobial activity against several human pathogens proves its ability to fight against several diseases and skin infections. The reason for the use of this plant in traditional systems of medicines can be supported by the various properties reported in modern scientific literatures published in the past decade. The plant is thus proved to be a valuable spice crop which offers many more pharmacological properties.

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