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Morphological, phytochemical, and pharmacological investigation of Black Turmeric (*Curcuma caesia* Roxb.)

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ABSTRACT

Background & Aim: *Curcuma caesia* Roxb., commonly known as "Black turmeric" is a perennial rhizomatous critically endangered herb available in Northeast, Central, and Southern India. The plant possesses various medicinal properties and remains an untouched plant among researchers and growers.

Experimental: In the current review keywords including black turmeric and medicinal properties, black turmeric and phytochemical, black turmeric and pharmacological application were searched in scientific websites such as PubMed, ResearchGate, and Google Scholar regarding plant description, distribution, chemical composition, and pharmacological investigation of black turmeric (*Curcuma caesia* Roxb.)

Results: The plant with bioactive compounds in form of carotenoids, flavonoids, saponins, tannins, phenolics, terpenoids, coumarins, anthraquinones, etc. possess antioxidant, anti-cancer, anti-asthmatic, smooth muscle relaxant, anxiolytic, bronchodilating, anti-convulsant, CNS depressant, locomotor depressant, anthelmintic, anti-bacterial anti-fungal, and anti-mutagenic activities. The potentiality of the rhizome as an antiviral agent against coronavirus has also been justified and under trial.

Recommended applications/industries: This review focuses on the description, phytochemical, and pharmacological investigation of the herb to explore its potentiality as an important medicinal plant with special emphasis on its preservation and cultivation among the growers.

1. Introduction

Traditional medicine and its uses, derived from ancient knowledge, skills, and practices show beneficial impacts on human health and disease management (Achour *et al*., 2022). They are the best alternative for modern medicine as they do not show side effects, are nature-based, and are economical (Pandey *et al*., 2022). The exploration of scientific techniques to conserve plant species and their medicinal values should be given priority for the sake of germplasm preservation and species extinction (Pandey *et al*., 2020).

Curcuma caesia commonly known as black turmeric, belonging to the family Zingiberaceae is a rare subtropical to temperate partial shade-loving plant occurring in Java, Myanmar,Northeast and Central India (Rajkumari and Sanatombi, 2017). In India, it is found in Orissa, West Bengal, Uttar Pradesh, Madhya Pradesh, and Chhattisgarh. The plant is also distributed in root hills of the Himalayas, Sikkim, east and west Godavari, Khammam district of Arunachal Pradesh (Pathan and Vandere, 2014). In Madhya Pradesh, the plant is designated as very felicitous, and if a person who owns it never have shortage of cereals and food (Donipati and Sreeramulu, 2015).

The plant is erect, rhizomatous, and about 1.0–1.5 m in height. The species grows at an altitudinal of 200–1000 m and prefers sandy loam, and acidic soils of pH

4.5–6.5. Rhizomes are oval in shape and acute at the tip. Leaves are long and broad, broadly lanceolate, glabrous, with a deep ferruginous purple cloud down the middle, which penetrates to the lower surface. Leaves generally arise from an underground rhizome. The leaves contain a deep red-violet patch, runing throughout the lamina. The plant shows spike inflorescence and flowers are pale yellow in color, with a reddish outer border and smaller than their bracts. Petiole and sheath are as long as the blade. Spikes appear before the leaves (Fig. 1). Flowers appear during the initiation of the monsoon and fruits mature at the end of the monsoon. The microscopic study of leaf shows upper and lower epidermis, mesophylly, and vascular bundles with oil cavities, the rhizome with single layer epidermis, 3-5 layered cortex, poorly developed epidermis and well developed pericycle, large parenchymatous pith and well-developed vascular tissues (Paliwal *et al*., 2011).

The plant is critically endangered thus modern breeding methods in vitro and in vivo biological activities regarding adverse effects, toxicity, and clinical potential of *C. caesia* should be preferred (Borah *et al.*, 2020). An attempt made to regenerate shoots on MS medium using Kn and GA3 reveals that they show 80% survival under field conditions without any growth promoter (Sarma and Deka, 2020). The plant possesses a wide application in the traditional system of medicine with a broad spectrum of activity on several diseases (Pathan *et al.*, 2013). The need for phytochemical analysis and pharmacological investigation of medicinal plants is significant as it provides valuable information on bioactive principles, and their use in preparing new drug formulations (Pandey *et al.*, 2018). Therefore, there is a need for vast studies of morphology, phytochemical constituents, and pharmacological activities of *Curcuma caesia* to identify various bioactive compounds and their uses in the medicinal and drug industries.

Fig. 1. *Curcuma caesia*- Plant and Rhizome

2. Phytochemical composition

The plant mainly contains turmingone, ocimene, borneol, cineole, bornyl acetate, camphor, and curcumin (Sharma *et al.*, 2021). Methanol, aqueous and chloroform extract of the rhizome shows the presence of phytosterols, terpenoids, saponins, quinones, oils, carbohydrates, saponins, proteins, flavonoids, diterpenes, amino acids, starch, glycosides, steroids, alkaloids, phenols, tannins, flavonoids, and resins (Donipati and Sreeramulu, 2015; Ranemma and Reddy, 2017; Yadav and Saravanan, 2019). The plant contains curcuminoids, demethoxycurcumin, bisdemethoxy curcumin (Baghel *et al.*, 2013) ar-tumerone, borneol, (Z) ocimene, bornyl acetate, ar-curcumene, elemene, curcumin, and 1,8-cineole (Mahato and Sharma, 2018). Acetone extract of rhizome shows the presence of phytochemicals like Alkaloids, Saponin, Tannin, Anthocyanin, Emodins, Flavonoids, Diterpenes, Phytosterol, Phenol, Phlobatannin, Leucoanthocyanin, Anthroquinone, Chalcones, Cardiac Glycosides, Carbohydrate (Sawant and Godghate, 2013). The GC-MS analysis of methanol rhizome extract isolated α-Santalol, Retinal, Alloaromadendrene, Ar-tumerone, Megastigma-3,7(E),9-triene, Benzene, 1-(1,5-dimethyl-4-hexenyl)-4-methyl, 5,8,11,14,17-Eicosapentaenoic acid, methyl ester, (all-Z), and Tricyclo [8.6.0.0(2,9)] hexadeca-3,15-diene, trans-2,9-anti-9,10-trans-1,10 (Pakkirisamy *et al.*, 2017). Similarly, GC-MS analysis of essential oil obtained from the rhizome shows the presence of camphor, eucalyptol, and epicurzerenone (Paw *et al.*, 2020).

HPTLC analysis revealed the presence of phenolic compounds, steroids, phenols, terpenes, and other organic compounds in Curcuma caesia extract (Hadem *et al.*, 2015). HPTLC profiles, HPLC, and mass spectrometry reported the presence of Calebin-A in 12 to 14 months old rhizomes, and an endophytic fungus O. brasiliensis present in the rhizome, can be an important source for natural production of calebin-A (Majeed *et al.*, 2019). The hydrodistillation of hydrosol of the rhizome at 100 ^{0}c yields components like oleic acid, n-hexadecanoic acid, eicosanoic acid, camphor, N-[4-bromo-n-butyl-2- Piperidinone, 1-tridecene, 1,3,5-trimethyl-benzene, 2,4-bis(1,1- dimethylethyl)-phenol, and (E)-5-octadecene (Fatt *et al.*, 2021).

3. Pharmacological investigation

The plant has been reported to possess high antimicrobial, antifungal, antioxidant, analgesic, anticonvulsant, anti-asthmatic, locomotive depressant, and anti-inflammatory activities (Sharma *et al.*, 2021). The methanolic extract of the rhizome shows anticarcinogenic activities and increases the production of the enzyme, alkaline phosphatase (ALP), alanine aminotransferase (ALT), serum transaminases, aspartate aminotransferase (AST), and cancer marker enzyme acetylcholine esterase (AChE) whose activities were ceased following the treatment of diethylnitrosamine (DEN) in mice (Hadem *et al.*, 2014). Methanol extract of rhizome shows analgesic activity in mice and anti-inflammatory activity in rats. The extract shows a significant effect on the acetic acid-induced writhing model and also proved to be an analgesic agent using the hot plate test. Further methanol extract also shows significant anti-inflammatory properties decreasing the dry weight of granuloma and paw edema volume in carrageenan-induced paw edema rats (Sawant *et al.*, 2014). The plant possesses anti-inflammatory and anticancer activity as In vivo studies reported that BALB/c mice exposed to DEN (diethylnitrosamine) show an increase in NF-κB and TNF-α binding activity and the plant extracts show potentiality in reversing this effect inhibiting tumor progression (Hadem *et al.*, 2015).

The aqueous, methanolic and ethanolic extract of rhizome possess antimutagenic activity inhibiting mutagen cyclophosphamide using *Salmonella typhimurium* bacterial strains TA98 and TA100 (Devi *et al.*, 2015). Methanol extract of rhizome possesses antitumor and antioxidant activity showing cytotoxicity on Ehrlich's ascites carcinoma-imposed cell line in mice, reducing tumor weight, tumor volume, viable cell count, and increasing the lifespan of the animal model (Karmakar *et al.*, 2013). The methanolic extract of the rhizome is a good chemotherapeutic agent and has the potential to scavenge the free radicals ABTS+ and O2 decreasing micronuclei formation, level of serum SGOT and SGPT, peroxidation in both kidney and liver, and increasing GSH and GR (Devi and Mazumder, 2016), along with antioxidant activity against DPPH scavenging (Yadav and Saravanan, 2019). The Hexane rhizome extract of the plant possesses anti-cancer properties inhibiting HepG2 cancer cell lines. The flow cytometry and western blotting prove that the extract ceases cell arrest at the G2/M phase resulting in Programmed Cell Death. The docking of twenty compounds with Tubulin (1SA0) and EGFR (1XKK) an epidermal growth factor, shows very effective binding with the ligands (Mukunthan *et al.*, 2017). The rhizome possesses anthelmintic activity as ethyl acetate extract at a higher dose causes paralysis and death of earthworms (Karim *et al.*, 2017).

The plant is an antioxidant agent as it reduces oxidative stress, possesses antibacterial activities, shows an anti-inflammatory property inhibiting inflammation of neurons, and is thus used in curing diabetic neuropathy (Grover *et al.*, 2019). The rhizome possesses antioxidant properties showing DPPH, nitric oxide, Hydroxyl radical, and Superoxide Anion scavenging activity, along with antimicrobial activity inhibiting *Staphylococcus aureus*. Further, ethanol rhizome extract shows anti-inflammatory activities inhibiting heat-induced hemolysis, protein denaturation, and proteinase action (Kalita *et al.*, 2019). Spectroscopy and Gas Chromatography-Mass Spectroscopy (GC-MS) analysis of methanol extract of the rhizome explores its antioxidant and antibacterial properties (Chaturvedi *et al.*, 2019). The essential oil obtained from the rhizome possesses antimicrobial activities against bacteria *B. subtilis* and *B. cereus*, and fungi *S. cereviaceae* (Paw *et al.*, 2020)

The plant with bioactive compound curcuzederone extracted from the chloroform fraction of rhizome mainly possesses anti-cancer activities (Al-Amin *et al.*, 2021). In silico analysis of ocimin, an active principle of Curcuma caesia (CC) rhizome shows an inhibitory effect on COVID-19 main protease and is found competitive with standard drug nelfinavir (Umadevi *et al.*, 2020). Ethyl acetate fraction II of essential oil prepared from methanolic extract of dried rhizome shows anxiolytic, anti-amnesia, and antidepressant activities when tested on Wistar albino female rats enhancing memory, antidepression and anxiolytic effects (Borah *et al.*, 2022).

4. Traditional uses

The rhizome is the only part of the plant used to cure various ailments. It is bitter, hot taste, sharp, with a pleasant odor. The plant possesses anti-fungal, anticonvulsant, CNS depressant activity, muscle relaxant activities, locomotor depressant, analgesic, antibacterial, antipyretic, insecticidal, larvicidal, and

antihyperglycemic properties (Dewangan, 2014; Venugopal, 2017). It is used to cure heart diseases and is a good brain tonic. The fresh and dried rhizomes of the plant have been used in the traditional system of medicine to treat asthma, bronchitis, leucoderma, piles, tumors, bruises, impotency, epilepsy, and menstrual disorders (Das *et al*., 2013; Kataki and Bhattacharjee, 2020; Prasad *et al*., 2021), etc. It is used to treat inflammations, inflamed tonsils, glands of the neck, tuberculosis, control bleeding, cuts or wounds, snake bites, epileptic seizures, joint pain, toothache, contusions, enlargement of the spleen, allergic eruptions, and gastric stress (Sahu and Saxena, 2013; Dennis, 2021).

5. Conclusion

In conclusion, black turmeric is an important plant with multiple uses. It has been less studied and its pharmacological and medicinal properties are not explored properly. The plant rhizome with various bioactive principles has wide scope in treating various diseases most recently being SARS- COV-2, the causal organism of Global pandemic Coronavirus. Therefore, there is an urgent need to conduct studies and research on the phytochemical composition and other medicinal benefits of rhizomes and leaves of the plant. In vitro propagation techniques to grow plants using various growth promoters will help to conserve this medicinal plant. Moreover, the local growers should be encouraged to cultivate and conserve the germplasm of the plant for prolonged uses.

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