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A review on ethnobotany and promising pharmacological aspects of an endangered medicinal plant, *Curcuma caesia* Roxb.

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Abstract: *Curcuma caesia* Roxb. is one of the rarest medicinal plants used traditionally for the mitigation of various ailments. It is now classified as an endangered species and through this review, an overview regarding the pharmacological benefits of this plant has been put forward. Information on the ethnobotany and phytochemistry along with pharmacological activities was retrieved from the electronic databases for the period from 1962 to 2019. A literature review of articles published in local magazines, conference papers, unpublished materials, and books on traditional and medicinal plants of India was also conducted. There is very little information on *C. caesia*is in the literature, which revealed its antimicrobial, antioxidant, and anticancer activities along with neuropharmacological, thrombolytic, anthelmintic, antiulcer, and antidepressant properties. The modern pharmacological studies have validated some of the traditional claims and uses. However, many aspects of this perennial herb have not been studied due to its limited availability and authenticity of the species. There is limited availability of the species as it has become an endangered crop due to its overexploitation as traditional medicine since ancient times. Being a critically endangered medicinal plant, conservation strategies using modern breeding techniques strongly warrant further research on in vitro and in vivo biological activities in different assay systems; toxicity, adverse effects, and clinical efficacy of *C. caesia* are recommended to be further studied.

Key words: *Curcuma caesia*, biological activity, ethnobotany, Indian traditional medicine, phytochemistry

1. Introduction

Curcuma caesia Roxb. (family Zingiberaceae) is an underutilized perennial herb, endemic to the North-Eastern and Central India (Paliwal et al., 2011; Borah et al., 2019). The bluish-black tuberous rhizomes have strong aromatic characteristics and medicinal properties. (Liu et al., 2013). This plant has been used since ancient times for the treatment of many diseases (Liu et al., 2013; Borah et al., 2019). Rhizome possesses numerous biological properties which have been used for centuries as traditional medicine. (Paw et al., 2019). The herbal practitioner uses its rhizome for its antitumor, antioxidant (Liu et al., 2013; Paw et al., 2019), antimicrobial and thrombolytic (Fathima et al., 2015) properties. *C. caesia* is reported to possess antiasthmatic and wound healing properties (Hadem et al., 2014). It is effective against fever, dysentery, and stomachache (Hadem et al., 2014). The rhizomes are also used by various tribes of India as traditional medicine for curing hemorrhoids, epilepsy, menstrual disorder, cancer, antihelminthic, leprosy, and it also acts as an aphrodisiac (Sasikumar, 2005; Pandey et al., 2013). Treatment of asthma, piles, leukoderma, hemorrhoids, inflammation, and bronchitis using leaf or rhizome extract (Mangaly and Sabu 1990; Khare, 2007) has been well-documented. The leaves have found their utilization as plasters in various disorders like lymphangitis and adenitis, etc. (Donipati and Sreeramulu, 2015).

In different parts of India, *C. caesia* is known by different vernacular names; Kali haldi (Hindi), Kola halodhi (Assamese), Shyrmitiong (Khasi), Nallapasupu (Telugu), Kariarishina (Kannada), Aihang (Mizo), Yaingangamuba (Manipuri), Kala haldi (Bengali) (Baghel et al., 2013), Yakanekeloti (*Adi* tribe of Arunachal Pradesh) (Behura and Srivastava, 2011), Homen (*Khamti* tribe of Arunachal Pradesh) (Sasikumar, 2005), and 'black turmeric' in English signifying its bluish-black rhizome.

Due to its wide range of traditional and medicinal uses, the knowledge of the utilization methods of *C. caesia* is very essential. Being a traditional medicinal plant, a few mini-reviews on its biological activities have been written.

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However, an in-depth critical analysis of the previous studies on *C. caesia* is needed. Therefore, this article is an attempt to critically analyze the phytochemistry, traditional uses, and medicinal uses of this important medicinal herb, and to highlight the limitations of previous studies. This compilation would certainly enhance the scope for future research on its potential medicinal properties and help in developing effective strategies for its sustainable utilization.

2. Botanical feature of the plant

C. caesia is usually erect (Figure 1a) and grows between 0.5 and 1.0 m in height (Das et al., 2013). The plant bears pale yellow colored, long, tubular flowers, with reddish border, which is smaller than bracts (Das et al., 2013; Baghel et al., 2013). It is characterized by the presence of a large underground-ovoid bluish-black rhizome (Figure 1b) (Baghel et al., 2013). The leaves of *C. caesia* grow in a bunch of 10–20 leaves, which is characterized by a deep violet patch that runs throughout the leaf lamina (Figure 1c). The petiole is ivory in color and encircles each other. They have parallel venation (Das et al., 2013). The rhizome is usually 2–6 cm in diameter and has camphoraceous sweet odor (Donipati and Sreeramulu, 2015; Sahu et al., 2016). The shape and size vary with the external surface bearing root scars, adventitious type root, and warts. Moreover, the rhizome is characterized by longitudinal circular wrinkles on the surface giving rise to nodal and internodal zones. The rhizome is the propagation material of the plant and it grows in subtropical to temperate region, in sandy loam, acidic soils of pH 4.5–6.5. The plant takes about 9 months to mature (Baghel et al., 2013).

3. Materials and methods

The scientific name of the plant was accessed and verified in The Plant List[1]. A literature review (in English) was conducted, and data was collected from various online scientific databases like Sci-finder, Google Scholar, Science Direct, Scopus, Springer, Willey, Taylor and Francis, and PubMed using the keywords "*C. caesia*", "medicinal properties of *C. caesia*", "phytochemistry of *C. caesia*", "*C. caesia*essential oil" and "pharmaceutical uses of *C. caesia*" and other related words. The papers published before December 2019 were accessed. A literature review was also made for articles published in local magazines, local conference papers, unpublished materials, and classic books of traditional medicinal plants of India. Forty nine articles have been complied and reported in this review article.

4. Ethnobotany

Since ancient times, *C. caesia* has been used as traditional medicine for treating various medicinal conditions. The rhizomes of *C. caesia* finds extensive use in food and traditional medicine as compared to the rhizome of *C. aeruginosa* and *C. zedoaria* (Liu et al., 2013). The dried rhizome and leaves of *C.caesia* are used for the treatment of fever, wounds, cancer, leprosy, asthma, piles, allergies, toothache, and other ailments in North-Eastern and Central India (Israr et al., 2012). Treatment using the leaf or rhizome extract of *C.caesia* against epilepsy, asthma, piles, leukoderma, hemorrhoids, inflammation, and bronchitis have been documented (Amalraj et al., 2016; Mangaly and Sabu, 1990; Khare, 2007). The paste of the rhizomes is used in the rheumatic arthritis. (Rastogi and Malhotra, 1998).

Adi tribes of the Dehang-Debang Biosphere Reserve, Arunachal Pradesh (India) uses fresh rhizome decoction as an antidiarrheic and against stomach ache (Kagyung et al., 2010; Mahato and Sharma, 2018). The pastes of fresh rhizomes are applied as a therapy for insect, snake and scorpion bites by the Khamti tribe of the Lohit district of Eastern Arunachal Pradesh (Mahato and Sharma, 2018). These tribal communities also use the paste of the rhizome as a cure for impotency and as an aphrodisiac (Sasikumar, 2005).

Dried powder of the rhizome is mixed with the powdered seeds of *Andrographis paniculata* as an effective herbal formulation for insect and snakebite (Kagyung et al., 2010). The rhizomes find their utilization for the treatment of fever, worm infection, cough, and dysentery. (Singh and Jain, 2003). The paste made by crushing the rhizomes is applied in cuts or wounds to stop bleeding and promote quick healing (Nawaz et al., 2011; Mahato and Sharma, 2018).

Books documenting the ethnopharmacology and medicinal plants of India have also mentioned other traditional uses of *C. caesia*. The fresh rhizome of black turmeric is used by the Lodha community of India and given orally to the cattle for more milk production (Jain, 1981). The rhizome is also reported to influence the human central nervous system (Jain, 1981). The leaf extracts are used for curing fungal and bacterial infections. Local people of North East India have been using *C. caesia* for ages to cure joint pain and toothache (Jain, 1981). The oral administration of rhizome extract is reported to cure ulcers. The local communities from the North-Eastern region of India use *C. caesia* for curing headache, rheumatic pains, and as carminative (Naik, 2004). It is also used as a stimulant by the tribal communities. Moreover, the rhizome of the plant is ground into a paste and used for its antimicrobial properties against infections and wounds (Singh and Jain, 2003).

The rhizome of the plant is used in some religious rituals of the tribal communities of North East India. They

[1] www.theplantlist.org

Figure 1. *Curcuma caesia* a) germplasm, b) rhizome, and c) leaves grown at CSIR-NEIST Experimental Farm, Jorhat, Assam (INDIA).

offer this plant to God, while praying as they consider this plant to be highly effective against various health ailments and are considered safe compared to synthetic drugs (Jain, 1981; Sen et al., 2011). There are also many superstitions based on *C. caesia* in India. Some tribal communities from Arunachal Pradesh believe that keeping the rhizome in the living room brings more money and better health to the household (Jain, 1981).

C. caesia has been used since ancient times in traditional medicine and extensively used by the local and tribal communities in India led to over-exploitation, which significantly decreased its population. Now it is classified as an endangered plant species (Das et al., 2013; Borah et al., 2019). There are several reports in the local and national print and electronic media regarding the illegal cultivation and trade of this endangered plant from North East India (The Telegraph, 2008). The local people are aware of the benefits of this plant and they sell illegally at high prices. Thus, the traditional reports on its health benefits need to be validated scientifically to prove/establish the mechanism of its pharmacological benefits and to ascertain toxicological effects if any. Proper conservation strategies need to be implemented for this important medicinal plant.

5. Phytochemistry

In order to study the medicinal properties of any plant, the first and foremost thing to understand is its chemical constitution. The phytochemical data ensures the identification and authentication of the plant during research investigations and traditional applications (Asif, 2013; Donipati and Sreeramulu, 2015). Besides, this information may help in standardization of extract used for any scientific study. Most of the studies reported are on the essential oil from the rhizome of *C. caesia*. A preliminary study indicated the presence of camphene, sesquiterpenes, bornylene, and δ-camphor in the rhizome essential oil of *C. caesia* (Sastri, 1962). The essential oil of *C. caesia* yielded through hydro-distillation is dark yellow in color with strong aroma (Figure 2). The rhizome essential oil was studied by Mukunthan et al. (2014) and

reported that major compound was tropolone (15.86 %) and minor compounds were ledol (3.27 %), β-elemenone (3.03 %), α-bulnesene (3.02 %), and spathulenol (2.42 %). Paw et al., (2019) have reported that the predominant components present in the rhizome essential oil of *C. caesia* were eucalyptol (28.55%), epicurzerenone (19.62%), and camphor (21.73%). The GC/MS analysis of the essential oil obtained byhydro-distillation of the crushed rhizome of *C. caesia* have shown that camphor (28.3%) and ar-turmerone (12.3%) were the major compounds while Z-β-ocimeme (8.2%), ar-curcumene (6.9%), 1,8- cineole(5.3%), β-elemene (4.8%), borneol (4.4%), bornylacetate (3.3%), γ-curcumene (2.8%), β-caryophyllene (2.6%), and endo-fenchol (2.3%) were the minor constituents (Paliwal et al., 2011). The rhizome essential oil was also analyzed by Banarjee et al. (1984) and reported almost similar composition, the major constituents being linalool (20.42%) and d-camphore (18.88%), ocimine (15.66%), 1-ar-curcumene (14.84%), and zingiberol (12.60%), while 1, 8-cineole (9.06%) and α-borneol (7%) were identified as the minor compounds.

The major compound, camphene of the rhizome essential oil of *C. caesia*, has its use in fragrance industries. It is used in the manufacture of synthetic camphor or as a camphor substitute. It is also used as plasticizer for resins and lacquers (Schmaus et al., 2006). It also has strong free radical scavenging capacity, which renders its antioxidant properties. Tropolone is used as an antioxidant compound in the cosmetic and pharmaceutical industries (Mukunthan et al., 2014). It can protect skin and hair against oxidative damage due to its excellent scavenging activity (Schmaus et al., 2006). Linalool, component of its essential oil also possesses antiinflammatory and analgesic properties (Kamatou and Vilijoen, 2008).

There is only a single study on the chemical composition of the leaf essential oil of *C. caesi*; using GC/MS has shown that the major constituents were eucalyptol (16.43%) and camphor (11.56%) (Borah et al. 2019). Eucalyptol is an industrially important product, which has a vast use in the production of mouthwash and cough suppressant. It can control the mucus secretion and asthma due to its antiinflammatory properties (Asif and Khodadadi, 2013). It is widely used all over the world in aromatherapy. Camphor is also a major compound used in the fragrance industries (Schmauset al., 2006). Thus, these compounds are useful in the pharmaceutical industries for developments of drug candidates. Sarangthem and Haokip (2010) reported the presence of curcuminoids, phenolics, flavonoids, essential oil, and alkaloids by solvent extraction of its rhizome. However, they merely reported the existence of this class of constituents as total phenolics, total flavonoids, etc.

Figure 2. Essential oil extracted from the leaves of *C. caesia* through hydro-distillation at CSIR-NEST, Assam (India).

Different chemical markers were identified for the poststorage and to control the quality of *C. caesia*, an endangered medicinal plant. The essential oil of *C.caesia* was analyzed by using proton nuclear NMR (^{1}H-NMR) and by GC/MS analysis four thermolabile sesquiterpenes namely furanodienone, curzerenone, germacrone, furanodiene, etc. A method was developed for both quality and quantity for harvesting and poststorage (Mahanta et al., 2019). These chemical markers can be used to study the different oleoresin profile of *C. caesia*.

The bioactive molecules present in *C. caesia* are responsible for its medicinal properties. Naturally occurring phenolic phytochemicals play an important role in cancer prevention and treatment, and studies have shown that *C. caesia* possesses good number of phenolic compounds (Huang et al., 2010). Phenols constitute a major group of plant secondary metabolites with a wide range of biological activities and chemical diversities. Due to their ability to chelate metals they display antioxidant activities along with free radical scavenging properties. They are found to be beneficial in

cancer and atheroscerosis. (Schmid-Scheonbein, 2006). The antioxidant, antimutagenic, and antiinflammatory activity of *C. caesia* is due to the presence of these phenolic compounds. Flavonoids are chemically classified as benzo-gamma-pyron class of naturally occurring compound possessing a wide range of biological activities. (Martinez-Valverde et al., 2002) and flavonoids can inhibit various enzymes (Asif and Khodadadi, 2013). The antioxidant activity of flavonoids is very strong, which makes *C. caesia* a strong antioxidant agent. Alkaloids present in *C. caesia* can be an important component of various pharmaceutical products and can be used in drug development (Amirkia and Heinrich, 2014), as alkaloids are used commercially in pharmaceutical products.

6. Pharmacological effects

Use of the rhizomes for medicinal purposes emerged from various bioactive compounds. Varying concentrations of essential oil has been used in the studies (ranging from 0.05 to 150 mg). IC_{50} values were calculated in order to determine the effectiveness of the essential oil used in the research studies. According to some previous reports due to the presence of some of the biological compounds in the plant such as phenolics and flavonoids (Borah et al., 2019), *C. caesia* have shown a number of pharmacological effects as mentioned below:

6.1. Antimicrobial activity

Since ancient times, people have used plant secondary metabolites as antimicrobial agents. In recent years, there has been a renewed interest in the use of plant parts as antimicrobial agents, as some of the synthetic antibiotics can become ineffective due to resistance by the human body (Cowan, 1999).

A study conducted by Banerjee and Nigam (1976) reported that the rhizome essential oil of *C. caesia* could inhibit the growth of fungi, *Curvularia oryzae*, *Aspergillus niger*, and *A. flavus*. Rajamma et al. (2012) reported that the oleoresins present in *C. caesia* rhizome essential oil is effective against *Staphylococcus aureus*, *Bacillus subtilis*, and *Escherichia coli*. The diameter of the zone of inhibition was measured and it was found that it is highly effective against *B. subtilis*. This can be related to the traditional use of the rhizome of *C. caesia* in healing infections and wounds. Borah et al. (2019) have found that the leaf essential oil inhibited the growth of the bacteria: *B .subtilis*, *B. cereus*, *S. aureus*, and *S. typhimurium*, and also prevented the growth of the fungi: *A. fumigatus*, *A.niger*, *Saccharomyces cerevisiae*, and *Candida albicans*. The assays were performed using disk diffusion method and the minimum inhibitory concentrations were determined, where *C. caesia* leaf essential oil showed maximum inhibition against *S. aureus* and *A. niger*. Previously, Hendry et al. (2009) reported that eucalyptol has antimicrobial properties against some microorganisms cultured in planktonic and biofilm cultures. Since eucalyptol is the major component and its synergetic effects may be inhibiting the growth of microbes resulting in good antimicrobial activity of *C. caesia* rhizome essential oil. Further studies by in vitro models as well as comparison to some positive control showing significant dose-dependent effect would be helpful in the use of *C. caesia* essential oil in pharmaceutical and aromatic products for curing various microbial infections.

6.2. Antioxidant activity

The antioxidant properties of *C. caesia* have been determined by studying its free radical scavenging activities. The antioxidant property of the free radical scavenging properties of the rhizome extracts of *C. caesia* was studied by Liu et al. (2013) using DPPH assay and it was reported that the methanolic extracts of *C. caesia* showed good antioxidant ability, as compared to *C. aeruginosa* and *C. zedoaria*. Mangla et al. (2010) also studied the antioxidant activity of *C. caesia* rhizome extracts and found similar results, with IC_{50} value of 862.35 µg for 2 mL of 500 µM concentration of DPPH. However, recent reports showed a high level of total antioxidant ability of *C. caesia* from the hexane rhizome extracts (1200 mg ascorbic acid equivalent/100g) as compared to the methanolic extracts (Mukunthan et al., 2014). The total phenolic content was found to be proportional to the antioxidant activity. Krishnaraj et al. (2010) reported that the phenol content and antioxidant activity of *C. caesia* rhizome extract is greater than *C. amada*. Rajamma et al. (2012) reported the antioxidant activity of the oleoresin isolated from *C. caesia* with IC_{50} value of 0.32 mg and a significant correlation of the total phenolic content and the antioxidant properties was noted. Another study on the antioxidant potential of essential oil of *C. caesia* leaf reported that the free radical scavenging activity and the reducing power activity of the leaf essential oil increases with the increasing concentration. The leaf essential oil is rich in flavonoids and phenol, which can render it the antioxidant properties (Borah et al. 2019).

The studies reviewed here showing in silico antioxidant assays are of less pharmacological relevance. The nonspecificity and potential susceptibility of the chemical assays make the outcomes untrustworthy. In vivo assays are needed to determine the clinical application of this plant. Moreover, the antioxidants derived from natural products are gaining importance in the last few years. Certain industries are trying to focus on replacing the synthetic antioxidants with the natural ones, as people prefer to use products that are environmentally friendly and safe to use (Caleja et al., 2017). Thus, such plants like *C. caesia* can be the source of natural antioxidants; which can be used in various cosmetics as well as pharmaceutical products (Caleja et al., 2017).

6.3. Anticancer properties

Cancer is a major disease affecting millions of people globally. There is a constant need for new drugs and therapies for treating this life-threatening disease. Nowadays, scientists are drawing attention towards producing naturally derived products for the treatment of cancer (Greenwell and Rahman, 2015). These natural products are less toxic and have fewer side-effects. Medicinal plants are a major source for such kind of compounds (Greenwell and Rahman, 2015). Hadem et al. (2014) analyzed the chemopreventive effects of *C. caesia* using a mouse model. The BALB/c mice were exposed to an established carcinogen diethylnitrosamine, which is widely used as an inducer of hepatocarcinogenesis, and it was observed that the methanolic extract of the rhizome of *C. caesia* can revert the structural abnormalities induced by diethylnitrosamine exposure. Moreover, the hexane rhizome extracts of *C. caesia* have been reported for their ability to inhibit proliferation of carcinoma cell line, human liver adenocarcinoma cells (HepG2) in a dose-dependent manner. Various apoptotic modifications like membrane zeosis and formation of apoptotic bodies were observed with hexane extract-treated cancer cells and the western blot analysis provides substantial evidence that hexane rhizome extracts induce apoptosis via activated mitochondrial pathway as expression of proapoptotic proteins (Mukunthan et al., 2014).These studies have reported the ability of *C. caesia* to inhibit the cancer cell proliferation, so future studies on the mechanism and the type of cell death caused by its compounds are suggested. The cytotoxicity of the compounds also needs to be studied further to establish the molecular mechanism involved in the anticancer properties of this important medicinal plant.

6.4. Neuropharmacological activities

Different neuropharmacological activities of *C. caesia* was studied by Karmakar et al. (2011), and it was reported that the rhizome has analgesic, anticonvulsant, muscle relaxant, and locomotor depressant, which shows antidepressant activity of the central nervous system. The study was conducted on mouse models. The toxicity of the plant was also checked, and it showed negative results, meaning that the plant is safe for commercial use. This data can be further scrutinized to develop potential drug molecule by isolating the compounds responsible for these activities. This study is a preliminary base indicating the neuropharmacological potency of this plant. It is estimated that 1 in 10 adults takes prescribed antidepressants, but those come with major side effects (Caleja et al., 2017).

6.5. Thrombolytic activities

Thrombolysis is the breakdown of blood clot; blood clots occur in the body when the body tries to repair the injured blood vessels (Lilicrap et al., 2009). Various synthetic thrombolytic drugs are available in the market. The thrombolytic activity of *C. caesia* was reported by (Fathima et al., 2015). They analyzed the percentage of clot lysis activity of the ethanolic extract of the rhizome and observed that the ethanolic rhizome extract showed 49.18% clot lysis. However, this report is not conclusive as the effect of various other extracts of *C. caesia* and comparison to positive controls was not studied. Future analysis using positive controls and comparison with other extracts could be helpful.

6.6. Anthelmintic activity

The anthelmintic activity of the widely used species of genus *Curcuma*, *C. amada*, and *C. caesia* was reported to have positive activity (Gill et al., 2011). This study analyzed four extracts of C. amada and C. caesia prepared with petroleum ether, dichloromethane, ethanol, and water at three different concentrations. The results indicated that the ethanolic extact of C. caesia paralyzed the earthworm, while ethanolic extract of both the plants very effectively caused death of earthworms. Hence, further studies are warranted to establish the dosage and formulations along with mode of application.

6.7. Antiulcer activity

An ulcer is a common gastrointestinal disorder which is seen among many people. Several synthetic drugs are available to treat ulcers. However, these drugs are expensive and are likely to produce more side effects when compared to herbal medicines (Tripathy and Rafat, 2016). Das et al. (2012) studied the antiulcer activity of the ethanolic extract of the rhizome of *C. caesia* on experimental animal models and reported LD_{50} value of 2000 mg/kg of the extract and confirmed that the rhizome extract possesses antiulcer activity, as they could lower the ulcer index, gastric acid volume, pepsin, free and total acidity of the test animals. Furthermore, detailed bioactivity studies will be required for proper validation and evaluation of *C. caesia* rhizome to be used as an antiulcer drug.

6.8. Toxicology

There are several reports regarding the toxic nature of essential oil, which could be very harmful to human health; therefore, toxic nature of any compound should be tested before commercial uses. A study conducted on the genotoxicity of the leaf essential oil of *C. caesia* (0.05 mg) has shown that the essential oil has no toxic effect on the growth of *Allium cepa* L. roots and the mitotic index of the cells (Borah et al., 2019). The cells were also assessed for chromosomal aberrations and no such harmful changes were noted. In the chromosome aberration test chromosome breakage, bridge, multipolarity, chromosomal clump, and chromosomal stickiness were the characters taken into consideration, as they are the results of mutation in cellular level (Borah et al., 2019). The genotoxic effect of *C. caesia* rhizome essential oil was accessed, and it was found that the plant has negative impact on *A. cepa* roots and the mitotic index of the cells (Paw et al, 2019).

However, except that, no other report is available regarding the genotoxic effect of *C. caesia*. Therefore, further in vivo toxicology experiments can lead to the establishment of *C. caesia* in pharmaceutical industries as well as food industries.

7. Conclusion and future perspective

C. caesia is one of the critically endangered plants with immense medicinal and therapeutic values. Advanced plant breeding techniques must be applied to develop new varieties of *C. caesia* with desirable traits. Dr. Lal group from CSIR-NEIST, Jorhat (India) has a vast collection of *C. caesia* germplasm and has created a genebank of 136 germplasm. They have been studying the biological activities of the *C. caesia* essential oil and are trying to develop new varieties with better traits (personal communication). Moreover, with a wide array of therapeutic uses further studies should be conducted to identify the different bioactive compounds corresponding to the respective medicinal properties of *C. caesia*. The current review attempts to highlight the pharmacological benefits of *C. caesia*, which can pave a new path for research towards its biochemical and molecular characterization. C. Caesia, rare and endangered herb is preserved by ethnic communities in the rural areas as they conserve them for their future generations owing to the curative attributes of the herb. Thus, the pharmacological benefits of these plants should be exploited and make them in high demand. Proactive conservative measures needs to be taken for this medicinally and economically important medicinal plant. However, an in-depth analysis in various in-vitro, in-vivo and in-silico models are recommended to delineate the mode of action and biological activities. The biological compounds identified and isolated, or its essential oil could be used in the formulation of natural drugs and could be a good alternative to synthetic medicines. In vitro toxicology studies have also shown it to be a safe product. Further research can lead to the use of *C. caesia* in the development of antimicrobial, anticancer, antioxidant, neuropharmacological, thrombolytic, anthelminthic, and antiulcer products as well as food supplements.

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Conflict of interest

The authors report no conflict of interest.

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