Abstract

The traditional system of medicine involves the use of different plant extracts for treating various ailments. The use of medicinal plants as medicines is based on the folklore remedies used in different parts of the world. *Curcuma caesia* is lesser known species of the genus and has been used for centuries as folklore medicines. On the basis of pharmacological attributes of this plant as authenticated by various scientific studies, the rhizome is considered as potent source of medicine over the synthetic drugs. Recent advances in the research work in this plant and submission of the gene sequences in the databases has prompted us to compile this review. It deals about the plant and all the scientific studies carried out to introduce the plant and bring awareness about lesser known species to the scientific community. Presence of medicinally important bioactive compounds in *Curcuma caesia* depicts that it has great potential for becoming a future drug.

Keywords: Bioactive compounds, *Curcuma*, ethnomedicine, pharmacological, traditional.

Introduction

The use of medicinal plants for the treatment of diseases is associated with rich knowledge of plants and their products in different ethnic communities present in different parts of the world. Medicinal plants can be considered as the backbone of traditional medicine and are widely used to treat a plethora of acute and chronic diseases all over the world (1). They are known as “Chemical Goldmines” due to the presence of natural chemicals, which are acceptable to human physiological system (2). With the advent of modern medicine, herbal based medicine suffered a setback, but due to the multiple drug resistance, side effects with antibiotics, restriction in use of synthetic antioxidant drugs and limited availability of anticancer drugs has forced the scientist to search for new substances from plant origin (3). And so, nowadays, there is a revival of interest with herbal-based medicine and the herbal drug industries is now a very fast growing sector in the international market (4). India has one of the richest ethno-botanical traditions in the world with more than 7000 species of plants found in different agro ecosystems and used by various indigenous systems of medicine (2). India is one of the world’s twelve leading biodiversity centres with the presence of over 45,000 different plant species, out of this about 15,000 - 20,000 plants have good medicinal properties of which only about 7,000-7,500 are being used by traditional practitioners (3). The Siddha system of medicine uses around 600, Ayurveda 700, Unani 700 and modern medicine about 30 plants species (5). Over 95% of the plants used are collected from the wild sources, leading to real danger of extinction of many important medicinal plants, so there is urgent need to conserve these natural resources and bring awareness about the lesser known medicinal plants. 

Non-Conventional Turmeric

*A Review on Non-Conventional Turmeric: Curcuma caesia Roxb*

Neha Behar¹, Tiwari, K. L.² and Jadhav, S. K.¹*

¹School of studies in Biotechnology, Pt. Ravi Shankar Shukla University, Raipur, Chhattisgarh, India.
²Department of Biotechnology, Guru Ghasidas Central University, Bilaspur, Chhattisgarh, India.
*For Correspondence - shailesh_07@sify.com*
The Genus Curcuma: The Zingiberaceae family constitutes a vital group of rhizomatous medicinal and aromatic plants characterised by the presence of volatile oils and oleoresins. The important genera coming under Zingiberaceae are Curcuma, Kaempferia, Hedychium, Amomum, Zingiber, Alpinia, Elettaria and Costus (2). The genus Curcuma has originated in the Indo-Malayan region (6). India has rich diversity of Curcuma, especially species and cultivar diversity (7). Out of the 100 or so species reported in this genus, about 40 are of Indian origin (8). The Genus Curcuma is gaining importance all over the world as a mighty cure to combat a variety of ailments, as it carries bioactive component credited with anti-inflammatory, hypocholesteremic, choleratic, antimicrobial, antitumour, antifibrotic, antiviral, antidiabetic, antitumour and anticancerous properties as well as insect repellent activity (9). Though Curcuma longa syn. (C. domestica) is the most commonly utilized species, other species such as C. caesia, C. aromatica, C. amada, C. kwangsiensis, C. zedoaria, C. malabarica, C. angustifolia, C. montana, C. decipiens, C. alismaefolia, C. thorelli, C. comosa etc. are also economically important. About 40 Curcuma species, 50 cultivars and 20 improved varieties of Curcuma longa and one improved variety of Curcuma amada are available in India (10).

Curcuma caesia: The plant: Curcuma caesia Roxb., commonly known as Black turmeric is a perennial herb with bluish-black rhizome. The rhizome of this plant is aromatic and yields an essential oil and has been traditionally used for centuries as a folklore remedy. The inner part of the rhizome emits a characteristic sweet smell, due to the presence of essential oil and so ‘Turkoms’ use these tubers as a rubifacient to rub their bodies after Turkish bath (11). Northern tribes use Black Turmeric as a talisman to keep the evil spirits away, while in West Bengal it finds an important place in traditional system of medicine and is also used as a substitute for turmeric in fresh state, in Madhya Pradesh also the plant is regarded as very auspicious and it is stated that a person who possesses it will never experience shortage of cereals and food (12). This clearly states that this plant is not only important medicinally but also important socially as well as spiritually.

Synonyms of Curcuma caesia in Indian and foreign Languages

<table>
<thead>
<tr>
<th>Language</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hindi</td>
<td>Kali Haldi, Nar Kachura,</td>
</tr>
<tr>
<td></td>
<td>Krishna kedar</td>
</tr>
<tr>
<td>Manipuri</td>
<td>Yaingang Amuba or yaimu</td>
</tr>
<tr>
<td>Marathi</td>
<td>Kala-haldi</td>
</tr>
<tr>
<td>Telugu</td>
<td>Nalla Pasupu, Manupasupu</td>
</tr>
<tr>
<td>Kannada</td>
<td>Kariarishina, Naru kachora</td>
</tr>
<tr>
<td>Bengali</td>
<td>Kala haldi</td>
</tr>
<tr>
<td>Mizo</td>
<td>Aihang, Ailaihang</td>
</tr>
<tr>
<td>Assamese</td>
<td>Kala haladhi</td>
</tr>
<tr>
<td>Arabic</td>
<td>Gadhwar aswad.</td>
</tr>
<tr>
<td>English</td>
<td>Black zedoary</td>
</tr>
<tr>
<td>French</td>
<td>Zédoaire noir</td>
</tr>
<tr>
<td>German</td>
<td>Schwarz zedoarwurzel</td>
</tr>
<tr>
<td>Italian</td>
<td>Zedoaria nera.</td>
</tr>
<tr>
<td>Malay</td>
<td>Temu hitam</td>
</tr>
<tr>
<td>Neplaese</td>
<td>Kaalo haledo</td>
</tr>
<tr>
<td>Turkish</td>
<td>Kara cadvar.</td>
</tr>
</tbody>
</table>

Significance of name: Curcuma caesia is vernacularly known as Kali Haldi (Black turmeric). The basic reason behind it is, as in West Bengal the rhizome of Curcuma caesia is used for worshipping Goddess Kali (Black), probably, for this reason it is popularly called as Kali Haldi in Hindi, inspite of the fact that in plant taxonomy, the word caesia means blue colour. In Mahabharata (The Epic of Hindus) Lord Krishna is depicted as blue skinned, hence the word Krishna can also mean blue colour by etymology so, Curcuma caesia is also called Krishna Kedara in Hindi since inside portion of the rhizome is blue coloured.

Neha Behar et al
Taxonomical classification

<table>
<thead>
<tr>
<th>Taxa</th>
<th>Rank</th>
<th>Scientific name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superkingdom</td>
<td>Eukaryota</td>
<td></td>
</tr>
<tr>
<td>Kingdom</td>
<td>Viridiplantae</td>
<td></td>
</tr>
<tr>
<td>Phylum</td>
<td>Streptophyta</td>
<td></td>
</tr>
<tr>
<td>Unranked</td>
<td>Embryophyta</td>
<td></td>
</tr>
<tr>
<td>Unranked</td>
<td>Tracheophyta</td>
<td></td>
</tr>
<tr>
<td>Unranked</td>
<td>Spermatophyta</td>
<td></td>
</tr>
<tr>
<td>Division</td>
<td>Magnoliophyta</td>
<td></td>
</tr>
<tr>
<td>Class</td>
<td>Liliopsida</td>
<td></td>
</tr>
<tr>
<td>Order</td>
<td>Zingiberales</td>
<td></td>
</tr>
<tr>
<td>Family</td>
<td>Zingiberaceae</td>
<td></td>
</tr>
<tr>
<td>Genus</td>
<td>Curcuma</td>
<td></td>
</tr>
<tr>
<td>Species</td>
<td>caesia</td>
<td></td>
</tr>
<tr>
<td>Binomial name</td>
<td>Curcuma caesia Roxb.</td>
<td>(13)</td>
</tr>
</tbody>
</table>

**Habitat:** *Curcuma caesia* is found in Java, India and Myanmar (14). Black Turmeric is native to North-East and Central India (15). It flourishes well in moist deciduous forest (16). It is also rarely found in Madhya Pradesh, Jharkhand, Chhattisgarh and Orissa (17).

**Tribal practices:** Even today, about 80% of the world's population relies on traditional plant based medicines for treating various ailments (18). *Curcuma caesia* plant is regarded as very auspicious and it is often used for magic remedies, tantric sadhana and medication by tribal people in various parts of India. In Chhattisgarh, the rhizome is used in dried powder form (Fig. 1 C) as folklore medicine for the treatment of wounds, cold, cough inflammation, leucoderma, tumors, piles, bronchitis, pneumonia, asthma, rheumatic pains, toothaches and infertility etc. Ethnomedicinal plants from Gohpur of Sonitpur district Assam was done and population used for the study was mainly dominated with assamese, Bodo, Mishing, Nepali and Santhal communities of local healers. They used fresh rhizome paste (50 g) mixed with *Musa balbisiana* fruit bark ash and applied once daily till cure in gout, sprains and bruises (19). Documentation of traditional herbal knowledge of Khamptis, a major tribe of the state of Arunachal Pradesh was done and found that they used crushed collar paste of *Curcuma caesia* plants to heal severe wounds and injuries (19).

An ethnombotanical survey among the Garo tribal healers to gather information of the plants, ailments, formulations, and dosages were obtained from the tribal healers inhabiting the Madhupur region in Bangladesh and *Curcuma caesia* is used in inflammation of tonsils (20). Not only rhizomes but the roots of *Curcuma caesia* are used in Unani medicines for dyspepsia, stomach and liver tonic (21). In Manipur, traditionally the rhizome is used for treating leucoderma, asthma, tumors, piles, bronchitis etc. The paste is applied in bruises, contusions and rheumatic pains (22). The rhizome is often used by the Baiga, Sahariya, Agariya, Gond, Korku and other tribal people of Madhya Pradesh state of India for the treatment of pneumonia, cough, cold in children and fever and asthma in adults (23).

**Status of plant in India:** The plant of *Curcuma caesia* is used in India for tantric sadhana and medication by tribal people, due to which it is overexploited and depleting faster. The National Medicinal Plant Board of India has listed 112 plants as crucially vulnerable species circulated by Ministry of Environment in 1997 and according to this, export of these species is not permitted without the permission of the legal competent authorities and this notification includes *Curcuma caesia* as well. This plant is in great demand in Central India and, due to indiscriminate exploitation the plant has been categorized as an endangered species (24).

Our state Chhattisgarh is known as “Herbal State” due to presence of wide varieties of medicinal plants. Floristic Study of the erstwhile seven district of Chhattisgarh was made by National Botanical Research Institute, Lucknow and identified 45 species as endangered taxa of the state and *Curcuma caesia* is also in this list. According to the Chhattisgarh State Medicinal Plant Board, 45 species including *Curcuma caesia* in the state has been identified as endangered species.

**Cultivation and Harvesting Methodology:** The cultivation and harvest practices are similar to
that of *Curcuma longa*. The propagating part of the plant is underground short and thick rhizome. The crop is grown in warm and moist regions. The soil should be sandy or clay loam and rich in humus. It can be grown in up to an altitude of 4000 feet above sea level. Small pieces of rhizome with a bud are sown 3 inches deep into soil in the months between April to August. The turning yellow of leaves and their fall in December to January indicate maturity of the crop. The rhizomes are then dug out leaving a few which serve as a seed for the next cropping season (25). The present harvesting practices of *Curcuma caesia* is very deteriorating because of high price of product in the national and international markets, immature collection by locals, poor regeneration. This may be the reason for the present status of the plant (26).

**Morphological Characters:** Syamkumar and Sasikumar (27) characterized 15 economically important *Curcuma* species and listed their important morphological characters. *Curcuma caesia* and *C. aeruginosa* have almost similar morphological characters and sometimes *C. aeruginosa* is misidentified as *C. caesia*, the only difference lies in ploidy level which is 63, colour of corolla is white and rhizome is viridis green in case of *C. aeruginosa* while *C. caesia* is a perennial herb with ploidy level as 42 and with following morphology.

**Floral Character:** Spike position - Central or lateral, Colour of calyx and corolla - Purple.

**Rhizome Character:** Colour of rhizome - Blue (Fig. 1 A), Aroma - Camphoraceous, Taste - Bitter

**Aerial Character:** Colour of leaf sheath and leaf midrib - Purple brown (Fig. 1 B).

Other morphological characters as described by other researchers are described as follows: Rhizome large, sessile tubers bluish grey inside; leaves large, oblong with a broad purple-brown cloud down the mid-rib; petiole long green, glabrous beneath; inflorescence spike appearing before leaves; fertile bract greenish; coma bract tinge with pink; flower pale yellow with bright yellow throat; calyx translucent white; corolla red (14). Verma *et al.*, (28) reported detailed HPTLC studies for quantitative evaluation of active marker component including morphological and histological parameters to establish the authenticity of *C. caesia* rhizome and to differentiate the drug from its other allied species. 

**Biochemical Component:** Curcumin, essential oil and oleoresin are the three most important biochemical components found in *Curcuma* spp. (10).

**Essential oil:** An earlier study showed that the rhizome oil of *C. caesia* contains 76.6% δ-camphor (29), but later Banerjee *et al.*, (30) reported that rhizome oil of *C. caesia* contains 1, 8-cineole (9.06%), ocimene (15.66%), 1-ar-curcumene (14.84%), δ-camphor (18.88%), δ-linalool (20.42%), δ borneol (7%) and zingiberol (12.60%). Behura (31) described the chemical composition of essential oil in rhizome as α-
Pinene (0.40), α-pinene (0.60), β-ocimene (E and Z) (2.1), camphor (7.73), linalool (0.99), caryophyllene (3.15), borneol (4.3), camphene (1.67), anethole (1.79) and cis-b-ocimene (14.54)

Furthermore, the essential oil of the rhizomes of *C. caesia* from Thailand was characterized by a high content of 1,8-cineole (30.4%) and appreciable amounts of camphor (10.8%), curzerene (8.8%) and curzerenone (5.8%). This significant variation in the camphor content of *C. caesia* and the search of new oil sources prompted for detailed GC–MS investigation of *C. caesia* (12). They found that volatile constituent of the rhizome oil from central India has major constituents as camphor (28.3%), ar-turmerone (12.3%), (Z)-β-ocimene (8.2%), ar-curcumene (6.9%), 1,8-cineole (5.3%), β-elemene (4.8%), borneol (4.4%), bomyl acetate (3.3%), α-curcumene (2.8%), α-caryophyllene (2.6%) and endo-fenchol (2.3%). They concluded that rhizome oil is deficient in camphor, compared with the oil studied earlier. Furthermore, Palival *et al.* (23) reported that the Gas Chromatography-mass spectrometry analysis of rhizome of Madhya Pradesh contains 1,8 cineole (27.48%), camphor (14-28.3%) as major constituent as well as ar-turmeone (12.3%). Behura and Shrivastava, 2004(32) also reported the essential oil content in the leaves as a-Pinene (1.5), b-pinene (6.3), myrcene (0.5), limonene (2.1), 1,8-cineole (27.0), camphor (1.68), linalool (2.8), b-elemene (2.4), borneol (8.7), a-terpenol (5.2) and eugenol (2.0).

Different authors have reported different profiles of essential oil found in *Curcuma caesia*. This anomaly may be due to environmental effects, varieties, maturity variations of the rhizome, analytical techniques and most important incorrect taxonomic identification of the specimens (10).

**Bioactive component:** The biological effects of turmeric is mainly attributed to its bioactive constituent, curcumin that has been widely used for its anti-inflammatory, antiangiogenic, antioxidant, wound healing and anti-cancer effects (33). In the rhizomes, curcumin and two related demethoxy compounds, demethoxy-curcumin and bisdemethoxy-curcumin, flavonoids and phenolic compounds which are widely distributed in plants have been reported to exert multiple biological effects. Sarangthem and Haokip (22) reported total curcuminoid as 78.4mg/g, volatile oil content as 6.75mg/g, total phenols as 60 mg/g, flavonoids as 30 mg/g, alkaloids as 104.25mg/g and soluble protein 47.5mg/g. This study showed that *Curcuma caesia* contain maximum curcuminoid, oil content, flavonoids, phenolics, different important amino acids, protein and high alkaloid content which reveals that the presence of these metabolites co-relates with its medicinal uses. A comparative study of phenol content and antioxidant activity of *Curcuma caesia* Roxb. and *Curcuma amada* Roxb. was done by Krishnaraj *et al.* (34), they reported that total phenol content and antioxidant activity were significantly high in *C. caesia* rhizome extract than the *C. amada* rhizome extract and although *C. amada* has already been introduced as a food additives, but there is no report available on the uses of *C. caesia* in food additives. Karmkarkar *et al.*, (35) conducted study to evaluate the methanol extract of *C. caesia* rhizome for some in vitro antioxidant studies associated with reactive oxygen species and reactive nitrogen species and concluded that the methanol extract of *C. caesia* possesses good antioxidant activity which may be potentially responsible for its anti-inflammatory and chemoprotective mechanism as well as using this plant’s extract as folkloric remedies. In *Curcuma caesia* alkaloids and tannins were found in addition to other metabolites while they were absent in *Curcuma longa*. In TLC profiling, the rhizome of both the *Curcuma* species showed presence of curcuminoinds while in leaves only methanolic extract in *C. longa* showed distinctable bands for curcuminoinds and in *C. caesia*, leaves showed only presence of curcumin while dis-methoxycurcumin and bis-demethoxycurcumin was found absent. Presence of medicinally important bioactive compounds in *Curcuma caesia* depicts that it has great potential for becoming a future drug for
treating various diseases (36).

**Pharmacological attributes of the bioactive compound:** Although *C. caesia* will have all the pharmacological attributes of *Curcuma* species due to presence of similar bioactive compounds but we have compiled only those research works which have been done in this species specifically.

The essential oils of *C. caesia* have been reported for both antibacterial and antifungal activities (37). Antifungal protein against *Candida albicans* has also been reported from *Curcuma caesia* Roxb. (Mannangatti and Narayanasamy) (38). *Curcuma caesia* is widely used in India as both an anti-inflammatory and anti-asthmatic in Ayurvedic medicine and preliminary mechanistic studies on the smooth muscle relaxant effect of hydro alcoholic extract of *Curcuma caesia* has also been reported (39). Neuropharmacological assessment of *Curcuma caesia* rhizome in experimental animal models was carried out to evaluate the methanol extract of *C. caesia* rhizome (MECC) and the study revealed remarkable analgesic, locomotor depressant, anticonvulsant and muscle relaxant effects of, demonstrating depressant action on the central nervous system and validated its traditional uses (40). Comparative evaluation of some plant extracts on bronchoconstriction in experimental animals was conducted, *Curcuma caesia* in 500 mg/kg showed significant protection against histamine induced bronchospasm (41).

**Biological attributes of phytochemicals:** Curcuminoids (curcumin, demethoxycurcumin, bisdemethoxycurcumin, methyl curcumin and acetyl curcumin), volatile oil components from rhizomes and leaves of *Curcuma* species besides ethanol, crude ether form and water extracts of turmeric powder as well as powdered turmeric are very important biologically. In fact, the relative proportion of the different curcuminoids plays a considerable role in its bioprotective activity (10). The chemical structures of the biologically active compounds are:

**Molecular Characterization in Curcuma caesia:** Molecular studies in this species are in very primitive stage. Molecular genetic

---

**Fig. 2.** Chemical structures of the pharmacological important curcuminoids.

Neha Behar *et al*
ngerprints of 15 *Curcuma* species including *Curcuma caesia* using Inter Simple Sequence Repeats (ISSR) and Randomly Amplified Polymorphic DNA (RAPD) markers to elucidate the genetic diversity among the species were formed. Thirty-nine RAPD primers yielded 376 bands of which 352 were polymorphic and out of the 91 bands produced by the 8 ISSR markers, 87 were polymorphic. Cluster analysis of data using UPGMA algorithm placed the 15 species into seven groups. *Curcuma caesia* and *C. aeruginosa* formed the fourth group in cluster II. The pairing of *Curcuma caesia* possessing deep blue coloured rhizome and camphoraceous aroma and bitter taste with *Curcuma aeruginosa*, having similar morphological and rhizome characters is very interesting. Between them they shared 72% similarity. Rhizomes of both the species are rich in camphor and their leaf midrib is having purple colour (42).

Intraspecific genetic diversity of four *Zingiber* species using Amplified Fragment Length Polymorphism (AFLP) markers was elucidated. *Curcuma angustifolia* was placed in a separate cluster I inferring to its wild nature while *Curcuma domestica II*, *Curcuma aromatica*, and *Curcuma caesia* were found to form a subgroup which shows a more precise discrimination among them. This can be explained that *Curcuma domestica II* and *Curcuma aromatica* are highlands species, possess geographic similarity and have a strong aroma, thus are found to be related. Dendrogram revealed that the species that are the derivatives of genetically similar type clustered more together (43).

Molecular genetic fingerprints were formed of nine *Curcuma* species from Northeast India using markers with the aim of elucidating there intra and inter-specific genetic diversity, important for utilization, management, and conservation. 12 random amplified polymorphic DNA, Nineteen Inter simple sequences repeats, and four amplified fragment length polymorphism primers produced 266 polymorphic fragments. ISSR confirmed maximum polymorphism of 98.55% whereas RAPD and AFLP showed 93.22% and 97.27%, respectively. The dendrograms based on three markers data were basically same with minor changes showing interspecific differences were more significant compared to intra-varietal ones. In RAPD cluster analysis, *Curcuma caesia* and *C. zedoaria* formed cluster I. All other species were grouped into the cluster II along with cultivated species. Cluster II formed 3 subgroups where in *C. spp.* is placed with *Curcuma amada* in subgroup 1 showing that the wild species does not make an independent cluster. The adjoined group of cultivated varieties with wild ones suggests that they have been evolved in course of time. *Curcuma domestica I*, II, and *C. aromatica* have physiological similarity of strong aroma and were also sub-grouped together in the RAPD dendrogram having least genetic distance. Coinciding with the results of RAPD, the clusters based on ISSR analysis divides the *Curcuma* species at their genetic distances segregating them more precisely. ISSR analysis has placed *Curcuma caesia* separately whereas other species were placed together with the cultivated species in another cluster. *Curcuma amada*, *C. angustifolia*, and *C. zedoaria* were found to be genetically closer to each other and placed in a single group inferring their vegetative and topological similarity also. AFLP markers separated the three varieties of a single species (*Curcuma longa, C. domestica I* and II) in two subgroups depicting that intraspecific variations also exist (44).

Molecular marker-based study of genetic variations facilitates in the delineation of *Curcuma* species in dendrograms which are suggestive of an evolutionary pattern among *Curcuma*. The results provided phylogenetic relationship between cultivated and wild relatives of *Curcuma*. ISSR fingerprinting opens new and interesting possibilities in the characterization of the *Curcuma* plants, which still awaits proper systematic identification. Exploration and evaluation of diversity would be of great significance for *in situ* conservation of important *Curcuma* species especially for their scientific and commercial programmes (44).
In vitro studies in Curcuma caesia: Curcuma is gaining importance globally as a potential source of drugs to combat a variety of ailments. Though earlier studies of Curcuma biotechnology were focused mainly on standardization of tissue culture protocols, recent attentions have been towards molecular biology aspects of the genus (45).

In vitro micropropagation: One of the earliest attempts on micropropagation of turmeric in India was that of Nadgauda et al., (46). They produce plantlets from young vegetative buds (sprouts) obtained from rhizome of two C. longa varieties. But first report on in vitro regeneration in C. caesia was reported by Balachandran et al., (47), they used rhizome sprouted bud of C. caesia, C. longa and C. aeruginosa in MS medium. MS along with BAP (3.0 mg/l) were found to be the best media. They concluded that there were significant differences between the treatments in the rate of multiplication in all the species except C. caesia. Then Tyagi et al., (48) developed in vitro plant regeneration and genotype conservation in eight varieties of Curcuma. They found 11.2 µM or 22.2 µM BAP as the best concentration of harmone for shoot regeneration in C. caesia. Bharalee et al., (49) reported In vitro clonal propagation of Curcuma caesia Roxb. and Curcuma zedoaria Rosc. from rhizome bud explants and MS + BAP (4.0mg/l) + NAA (1.5mg/l) was found to be most suitable for multiple shoot regeneration in C. caesia. Mohanty et al., (17) used sprouted rhizome buds of C. caesia as explants on MS media with various combination of BAP, IAA, NAA and kinetin. The percentage of explants forming shoots was highest in MS + BAP (3mg/l) + IAA (0.5mg/l). A higher concentration of BAP was found to be inhibitory for shoot initiation and kinetin alone had no role in shoot multiplication.

In vitro Conservation: Balachandran et al., (47) developed short term conservation of In vitro grown plants of C caesia. They used polypropylene caps for enclosure of the culture and they found that the plants remained green and alive for 7 months and multiplied after subculturing, while the cultures enclosed with cotton plugs dried within 2.5 months, the reason proposed was that there is slow water loss in tubes with polypropylene enclosures. Tyagi et al., (48) conserved C. caesia in vitro regenerated plants in 23.2µM kinetin supplemented in MS media and for about 323 days the plants remained alive and green.

In vitro microrhizome development, In vitro pollination, In vitro mutation as well as genetic transformation protocol has also been developed in C. longa but there is no report in C. caesia.

Genetic stability studies of micropropagated plants: The In vitro micropropagation technique is an alternative to conventional method of vegetative propagation for rapid clonal multiplication of the plants. The genetic stability of in vitro conserved plants is of utmost importance for commercial utilization of the technique for large scale production of true to type plants. The work regarding the extent of genetic stability of micro propagated C. caesia was done by Mohanty et al., (17). They reported that tissue culture raised plants of C. caesia could be conserved in vitro through subculturing in an interval of 4 months and the genetic stability of micropropagated plants was studied with interval of 6 months up to 30 months in culture using cytophotometric, RAPD, ISSR analysis. Cytophotometric analysis of 151 plants revealed a unimodal distribution of the DNA content with a peak corresponding to 4C nuclear DNA and RAPD as well as ISSR analysis showed monomorphic bands in all 73 regenerants, thus confirming genetic uniformity among in vitro grown somaclones of C. caesia.

Conclusion
Curcuma caesia is non-conventional, lesser known turmeric because of its limited bioavailability. The plant is an important medicinal plant used by folk people for various ailments and is considered very auspicious in Chhattisgarh and Madhya Pradesh, as they believe that, person who posses it will never have shortage of food, it has the same sacred value as Tulsi.
have in common Indian houses. The plant has now gained the status of endangered species and is on the verge of extinction due to various unfavourable factors and overexploitation. Thus efforts should be made to conserve and work for the betterment of this plant species. On the basis of pharmacological attributes of this plant, the rhizome can be considered as good source of medicine over the synthetic drugs. Recent advances in the research work in this plant and submission of the gene sequences in the databases has prompted us to write this review. This is the review compiling all the research done in every aspect of the plant which will be helpful to the researchers who plan in future to work in this plant species.

References


