STM JOURNALS

Research & Reviews: Journal of
Herbal Science

https://journals.stmjournals.com/rrjohs

ISSN: 2278-2257 (Online)
ISSN: 2348-9553 (Print)
Volume 13, Issue 3, 2024
September–December
DOI (Journal): 10.37591/RRJoHS

Review RRJoHS

A Review on Phytochemistry and Pharmacological Properties of *Curcuma amada (Zingiberaceae)*

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Abstract

Plant has been employed in traditional medicine since ancient times. Curcuma amada Roxb. (Mango ginger), is a member of Zingiberaceae family and the Curcuma genus. It is a distinctive spice that shares a similar appearance with ginger but provides a raw mango taste. It is considered as a valuable plant in traditional medicine which plays a crucial function in both the food and pharmaceutical industries. Ayurveda and Unani medicinal traditions highly value mango ginger for its properties as an appetizer, antipyretic, diuretic, aphrodisiac, emollient, alexteric, expectorant, and laxative. It is also used to treat biliousness, itching, skin problems, bronchitis, asthma, hiccough, and inflammation resulting from accidents. Mango ginger exhibits a wide range of pharmacological activities, including antioxidant, anthelminthic, antibacterial, antifungal, anticancer, anti-inflammatory, platelet aggregation inhibitory, antidiabetic, brine-shrimp lethal, biopesticide, enterokinase inhibitory, CNS depressant and analgesic activities. The plant contains significant quantities of starch, minerals, vitamins, phenolic acids, volatile oils, curcuminoids, and phytoconstituents, such as amadaldehyde, labdane diterpene dialdehyde, difurocumenonol, zederone and amadannulen. C. amada also have a vital function in diverse industrial applications, providing sustainable solutions in multiple sectors. They provide essential raw materials for the food industry, such as edible oils and natural flavorings, and are integral to pharmaceuticals for producing medicines and herbal remedies. Its components, such as essential oils and extracts can be used in cosmetics to improve the effectiveness of skincare and personal care products. This review aimed to focus on the plant's morphological characteristics, background, chemical properties, pharmacological properties and industrial applications.

Keywords: *Curcuma amada*, *Zingiberaceae* family, pharmacological activities, phytoconstituents, industrial applications

INTRODUCTION

The plant-derived products have been known to treat various health ailments since ancient times [1]. Currently, there is a significant focus on utilizing plant-based raw materials in the pharmaceutical industry due to their cost-effectiveness and minimal adverse effects [2]. The bioactive metabolites found in *Zingiberaceae* plant members make them highly valuable in the food processing, pharmaceutical, and nutraceutical industries. The *Zingiberaceae* is the well-known plant family consisting of 50 genera and around 1400 species [3, 4]. The plants belonging to this family are primarily rhizomatous and possess notable aromatic, medicinal, nutritional, and decorative characteristics [5].

Curcuma amada (Figures 1(a) and (b)) (Mango ginger) is one of the members of *Zingiberaceae* family known to have a high content of phytochemicals in its rhizome. It has a

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Received Date: August 01, 2024
Accepted Date: August 28, 2024
Published Date: September 03, 2024

Citation: Nikita Bindal, Sujata Mohanty. A Review on Phytochemistry and Pharmacological Properties of *Curcuma amada* (*Zingiberaceae*). Research & Reviews: Journal of Herbal Science. 2024; 13(3): 10–20p.

morphological resemblance with ginger having raw mango like flavor [6]. The flavor has been linked to the presence of car-3-ene and cis-ocimene [7]. From ancient times, this plant has been utilized to cure a wide range of illnesses in the Ayurvedic and Unani medical systems including cancer, asthma, appetizer, alexiteric, laxative, bronchitis, antipyretic, skin illnesses, hiccough, diuretic, and inflammation [8–10]. Additionally, *C. amada* has several medicinal qualities, including antioxidant activity, antibacterial, anti-inflammatory, analgesic, anticancer, and anti-hyperglyceridemic effects [9, 11, 12]. The presence of several bioactive substances, such as phenolics, tannins, alkaloids, saponins, flavonoids, curcumin, demethoxy curcumin and bis-demethoxy curcumin, etc., may explain the medicinal activity [13].

Figure 1. (a) *Curcuma amada* plant, (b) Rhizomes of *C. amada*.

TAXONOMY

- Kingdom: Plantae
- Phylum: Magnoliophyta
- Class: Monocotyledonae/ Liliopsida
- Order: Zingiberales
- Family: *Zingiberaceae*
- Genus: *Curcuma*
- Species: *Curcuma amada*

PLANT DESCRIPTION AND DISTRIBUTION

C. amada is a perennial, rhizomatous herb with an average height of 60–90 cm. The rhizome is large and bulky, and its morphology is very similar to *Curcuma longa*. The rhizome color is pale yellow with raw mango like fragrance and divided into nodes and internodes [13–15]. The leaves are in the form of tuft having 5–6 leaves on each plant and characterized as long, radical, sheathed, lanceolate, oblong, petiolate. It is widely grown in Asia, Africa and Australia. It is found in various parts of India including West Bengal, Karnataka, Gujrat, Uttar Pradesh, Kerela, Tamil Nadu, hills of Western coast and Northeastern states of India [10, 16].

CHEMICAL COMPOSITION

C. amada species is rich in nutrients, carbohydrates, fibers, essential oils, proteins, amino acids, minerals, and vitamins [10]. *C. amada* contains distinct phytochemicals in both its leaf and rhizome. The phytochemical screening has been performed with various aqueous and organic solvents [10, 17]. As a result of different experiments, several compounds, such as coumarin, cardiac glycosides, phytosterol, tannin, alkaloids, gum chloroform, terpenoids, and flavonoids were identified using chloroform, ethanol, methanol and water extracts [10]. The results of phytochemical analysis revealed that the methanolic

Table 1. The pharmacological activities of the identified compounds in *Curcuma amada*.

Compound	Class	Molecular Formula	Activity	References
Caffeic acid	Phenol	$C_9H_8O_4$	Antioxidant, antibacterial, antiviral, antitumor, anti-inflammatory and neuroprotection, effects and the ability to regulate blood glucose and blood lipids.	[28]
Ferulic acid	Phenol	$C_{10}H_{10}O_4$	Antioxidant, antibacterial, antiviral, antitumor, anti-inflammatory and neuroprotection, cardioprotective, antidiabetic.	[29]
Cinnamic acid	Phenol	$C_9H_8O_2$	Anticancer, antitumor, neuroprotective, antidiabetic, antimicrobial, antiparasitic, antioxidant, anti-inflammatory.	[30]
Curcumin	Curcuminoids	$C_{21}H_{20}O_6$	Antioxidant, vascular protector, wound healing, anticarcinogen, hepatoprotective, neuroprotective, metal toxicity reducer.	[31]
Demethoxy-curcumin	Curcuminoids	$C_{21}H_{20}O_6$	Anti-inflammatory, anti-proliferative.	[32]
Bis-demethoxy curcumin	Curcuminoids	$C_{19}H_{16}O_4$	Anti-inflammatory, anti-proliferative.	[32]
Mycerene	Monoterpene	$C_{10}H_{16}$	anxiolytic, antioxidant, anti-ageing, anti-inflammatory, analgesic, antibacterial, antidiabetic, antibacterial.	[33]
Epicurzerenone	Sesquiterpenes	$C_{15}H_{18}O_2$	Antimicrobial, antioxidant and cytotoxic activities.	[34]
Curzerenone	Sesquiterpenes	$C_{15}H_{18}O_2$	Anticancer, antiviral, antioxidant, vascular relaxation, hepatic fibrosis, platelet aggregation inhibitor, anti-inflammatory.	[35]
Curzerene	Terpenoid	$C_{15}H_{20}O$	Anticancer, antiproliferative, anti-inflammatory, antifungal, analgesic.	[36–39]
Camphor	Monoterpenoids	$C_{10}H_{16}O$	Antimicrobial, antiviral, antioxidant, analgesic and anti-cancer.	[40]
Isoborneol	Terpene	$C_{10}H_{18}O$	Anti-inflammatory, analgesic, antipyretic, inducing resuscitation, and widely applied in the protection and treatment of cardiovascular and cerebrovascular diseases.	[41]
Camphene	Terpenoid	$C_{10}H_{16}$	Antibacterial, antifungal, anticancer, antioxidant, antiparasitic, antidiabetic, anti-inflammatory, and hypolipidemic activities.	[42]
Borneol	Terpene	$C_{10}H_{18}O$	Anti-inflammatory, analgesic, antipyretic, inducing resuscitation, and widely applied in the protection and treatment of cardiovascular and cerebrovascular diseases.	[41]
β-pinene	Monoterpenoid	$C_{10}H_{16}$	Antiviral, antidepressant, and phytotoxic.	[42, 43, 44]
(E)-β-ocimene	Monoterpene	$C_{10}H_{16}$	Attraction of several types of pollinators to the flowers, defensive roles in vegetative plant tissues by mediating tritrophic interactions with parasitoids and predators of herbivores.	[45]
(*Z*)-β-farnesene	Sesquiterpene	$C_{15}H_{24}$	Production of lubricants, surfactants, and cosmetics.	[46]
α-longipinene	Sesquiterpene	$C_{15}H_{24}$	Inhibits hyphal growth.	[47]
Thymol	Monoterpene	$C_{10}H_{14}$	antioxidant, anti-inflammatory, local anaesthetic, antinociceptive, cicatrizing, antiseptic, and especially antibacterial and antifungal properties.	[48]
α-zingiberene	Sesquiterpene	$C_{15}H_{24}$	Chemo-preventive activity.	[49]
β-sesquiphellandrene	Sesquiterpene	$C_{15}H_{24}$	Anticancer.	[50]
Mangiferin,	Xanthonoid	$C_{19}H_{18}O_{11}$	Anticancer, anti-inflammatory, antioxidant, antivirus, immunomodulatory, neuroprotective.	[51]
Difurocumenonol	Terpenoid	–	Antibacterial.	[26]
Amadannulen	Terpenoid	$C_{24}H_{40}O_3$	Antioxidant, antimicrobial.	[26]
Amadaldehyde	Terpenoid	–	antioxidant activity, cytotoxicity and platelet aggregation inhibitory activity.	[27]

extract exhibited abundance of phytochemical compounds, including carbohydrates, proteins, alkaloids, flavonoids, tannins, phenolics, saponins, and fiber [17]. The phenolic acids present in mango ginger are caffeic, gentisic, ferulic, gallic, cinnamic, protocatechuic and small amounts of syringic and p-coumaric acids [11]. A wide variety of volatile and non-volatile bioactive chemicals, including curcumin, demethoxy curcumin, bis-demethoxy curcumin, phenol, terpenoids, and -mycerene, were identified in this plant with immense therapeutic effects, e.g., antibacterial, antioxidant, anti-inflammatory, analgesic, anti-cancer, anti-hyperglycemia, antidiabetic and antiobesity, etc. [11, 12, 18–21]. The leaf essential oil of *C. amada* mainly contains epi-curzerenone (10.76%), curzerene (3.95%), curzerenone (9.53%), and furanogermenone (1.77%), isoborneol (7.30%), Camphor (17.90%), borneol (1.87%), camphene hydrate (1.25%) and camphene (3.57%), whereas the rhizome essential oil contains monoterpenoids (97.72%), myrcene (88.84%), β-pinene (3.74%), (E)-β-ocimene (2.61%) and other minor constituents [22]. Another study done by Mustafa et al. (2005) revealed the presence of (*Z*)-β-farnesene (21.9%), 6,9-guaiadiene (19.8%), α-longipinene (14.8%), α-guaiene (14.5%), camphor (5.5%) and thymol (4.9%) [23]. In another study, α-zingiberene, β-sesquiphellandrene, and cuparene were the major compounds characterized in the profile of *C. amada* [13]. A compound named mangiferin, found in *C. amada*, was isolated using microwave aided extraction (MAE) with ethanol [24]. Also, three terpenoids, namely amadaldehyde, difurocumenonol, and amadannulen, were extracted from the chloroform extract of *C. amada* rhizome [25–27]. The pharmacological activity of the above compounds are described in Table 1.

TRADITIONAL USES

C. amada is widely used for culinary preparation and therapeutic reasons since ages. The rhizomes of *C. amada* used as an appetizer, alexteric, antipyretic, aphrodisiac, laxative diuretic, expectorant, antipyretic and appetizer as mentioned in the oldest system of medicine in India, Ayurveda and Unani [11]. Furthermore, it acts as a main component in pickles, sweets, sauces, curries, salads and used as a preservative [16]. The rhizome of this plant possesses carminative qualities, and has historically been utilized for the treatment of wounds and cuts [52]. Applying rhizome paste externally has been a long-standing tradition for treating sprains and skin problems [53]. In the northern region of Bangladesh, this plant is used as a folk remedy to treat various problems of respiratory, gastrointestinal, and rheumatic conditions. Aqueous extract of dried rhizome powder is used orally for the treatment of respiratory and gastrointestinal disorders, while paste is wrapped or rubbed on aching joints in cases of rheumatism [54].

PHARMACOLOGICAL ACTIVITIES

There are various recognized pharmacological actions of *C. amada*. As a result, it is utilised as traditional medicine in several countries. Some of the pharmacological and therapeutic qualities are listed below (Figure 2).

Antioxidant Activity

Antioxidants are crucial for the treatment and prevention of diseases, as they maintain human health by reducing oxidative stress. Hence, it is important to assess the antioxidant activity/capacity of foods and biological samples to guarantee the excellence of functional foods and to appraise the efficacy of dietary antioxidants in the prevention and treatment of diseases linked to oxidative stress [55, 56]. Antioxidant activity can be measured by using variety of assays. In a study, different extracts (hexane, chloroform, ethyl acetate, acetone, methanol and water) of *C. amada* rhizome were tested for DPPH scavenging activity, lipid peroxidation inhibition, superoxide scavenging activity and metal chelating activity. From the results, it was observed that polar extracts showed potential activity with all the tests performed whereas, non-polar extracts only showed lipid peroxidation inhibitory and metal chelating activity [24]. The petroleum ether extract demonstrated potent DPPH radical scavenging action, with an IC_{50} value of 18.98 ± 0.05. Additionally, it exhibited a high reducing power, with an A_{700} value of 0.861 ± 0.001. The ethyl acetate extract exhibited substantial nitric oxide radical scavenging activity, with an IC_{50} value of 5.97 ± 0.09, which was more than that of ascorbic acid (IC_{50} = 6.05 ± 0.02). The essential oil shown significant ability to scavenge superoxide radicals, with an IC_{50} value of 15.30 ±

0.03 µg/ml which was like that of ascorbic acid, having IC_{50} value of 15.28 ± 0.01 [12]. The antioxidant activity of the leaf and rhizome of *C. amada* was assessed using the DPPH scavenging method, with ascorbic acid as the standard. The antioxidant activity of the acetone extract of the rhizome was found to be higher than that of the methanol extract, according to a study by Sutar et al. in 2019 [9]. The ethanol extract also showed antioxidant potential [20, 57]. A novel compound Amadannulen was identified in the chloroform extract of *C. amada* rhizome which also exhibit antioxidant potential [26].

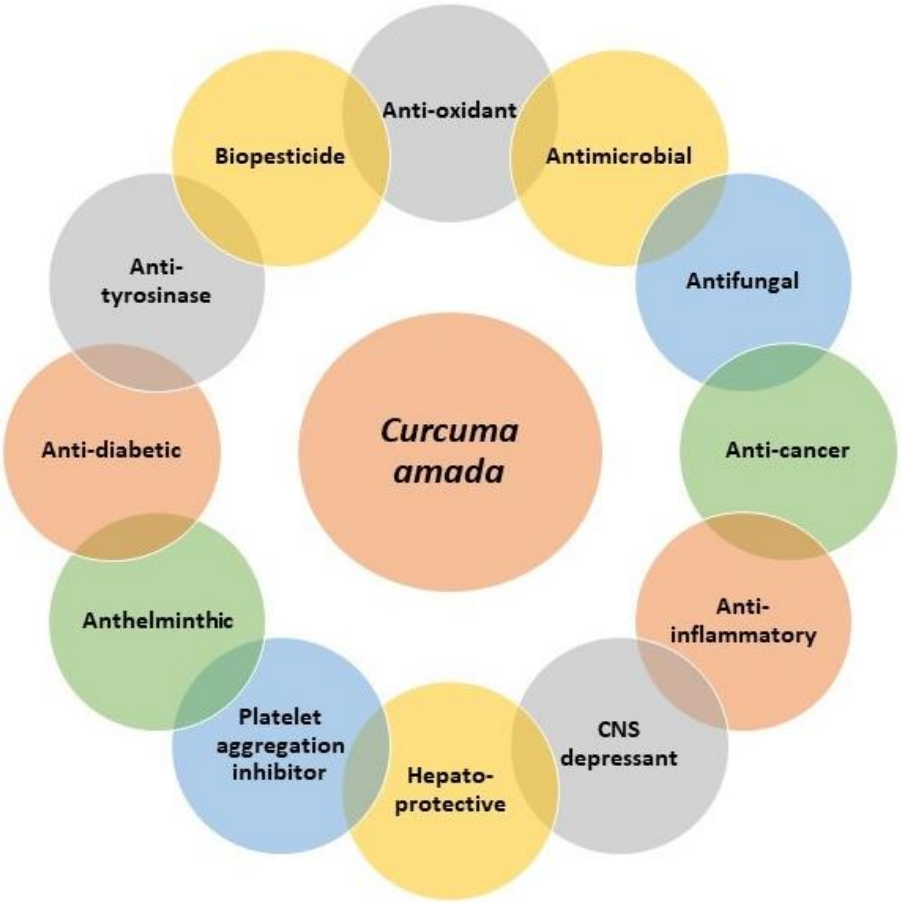

Figure 2. Overview of pharmacological and other properties associated with *C. amada*.

Anthelminthic Activity

The anthelminthic activity was conducted with different extracts (cyclohexane, ethyl acetate, methanol, aqueous) of *C. amada* rhizome in various concentration using Indian earthworms (*Pheretima posthuman*). The results indicated that all extracts of *C. amada* had anthelmintic activity that varied depending on the dosage, when compared to the conventional medicine albendazole. However, the methanol and aqueous extracts exhibit the most significant activity among them [58]. Ethanol and dichloromethane extracts of *C. amada* rhizome also known to have anthelminthic activity at various concentrations [59].

Antimicrobial and Antifungal Activity

From the previous studies, it was found that the different extracts of *C. amada* rhizome possess antimicrobial and antifungal activity, e.g., *Escherichia coli*, *Bacillus subtilis, Candida albicans*, etc. The ethanol extract showed antibacterial activity against *Streptococcus mutans* [60]. In another study, three extracts (petroleum ether, dichloromethane and chloroform) were tested against 10 microbial and 4 fungal strains and showed activity against all used bacterial and fungal strains [61]. *C. amada* of methanol extract has shown antibacterial activity against *Escherichia coli* and *Bacillus subtilis* [16]. Moreover, the *C. amada* essential oil exhibited antifungal activity against dermatophytes and yeasts [62].

Hepatoprotective Activity

In a previous study, rats were orally fed with the 50% ethanol extract of *C. amada* at dose levels of 100 mg/kg and 200 mg/kg. The result demonstrated that *C. amada* exhibits a potent hepatoprotective action at a dosage of 200 mg/kg [63]. Another study also revealed that the ethanol extract of *C. amada* rhizome has medical efficacy against CCl_4 induced hepatotoxicity in rats [64].

Antidiabetic Activity

In a study conducted by Kaliaperumal K. et al. (2024), Streptozotocin (STZ)-induced rat model system was used for the antidiabetic study [65]. This study revealed that the administration of the aqueous extract of *C. amada* rhizome resulted in a considerable rise in the body weight of diabetic rats by approximately 34.29 g, as well as a drop in their blood glucose level. Additionally, it demonstrated a reduction in creatinine and urea levels, as well as an improvement in insulin and glycogen levels and tissue recovery from STZ-induced damage, as compared to the effects of the Glibenclamide medication in diabetic rats [65]. In another study, *in-vitro* antidiabetic activity was conducted with Zinc-oxide (ZnO) nanoparticles (NPs) using *C. amada*. The findings demonstrated that the ZnO NPs and water extract of *C. amada* exhibited the alpha amylase and alpha glucosidase inhibitory activity [66]. The hydro-methanolic extract of *C. amada* rhizome also decreases the glucose level in blood in normal, alloxan induced and STZ-induced diabetic mice [67, 68].

Anti-Cancer Activity

Jambunathan et al. (2014) investigated the cell death causing ability of the *C. amada* rhizome methanol extract [69]. The outcomes of the study showed that the breast cancer cell lines MCF-7 and MDA Mb 231 were significantly affected by the methanol extract of leaves and rhizomes [69]. A further investigation was done using a supercritical CO_2 extract of mango ginger with human glioblastoma cell line (U-87MG) which revealed that mango ginger showed more cytotoxicity when compared to temozolomide, etoposide, curcumin, and turmeric [70]. Various *in-vitro* studies have been done using various cell lines like breast cancer cell line (MCF-7), baby hamster kidney cell (BHK-21), human lung cancer cell line (NCI-H460), etc. using various assays like MTT and Neutral red; it was observed that different extracts of *C. amada* rhizome has anti-cancerous potential [71–73].

Anti-Inflammatory Activity

C. amada possesses anti-inflammatory properties that are beneficial in treating inflammations resulting from injury, liver inflammation, arthritis, and rheumatism [10]. This effect was observed on Carrageenan-induced rat paw oedema model. The study revealed that the ethanol extract of *C. amada* rhizome exhibit anti-inflammatory effect in dose-dependent manner in both acute and chronic model due to presence of chemical compounds including hydroxyl, carbonyl, ester, and olefin [74]. In an *in-vitro* study, it was found that the ethanol and methanol extracts of *C. amada* rhizome has anti-inflammatory potential [52].

Anti-Tyrosinase and Anti-Melanogenic Activities

The tyrosinase inhibitory assay was performed with different varieties of curcuma species and arbutin as standard. From the results, it was found that the methanol extract of C. amada showed maximum tyrosinase inhibitory effect. The methanol extract was further sequentially extracted with water, n-hexane and ethyl acetate and ethyl acetate fraction showed maximum inhibitory activity. Moreover, the isolated compounds from ethyl acetate fractions were tested for intracellular anti-tyrosinase and anti-melanogenic activity with B16F10 melanoma cells. The isolated compounds showed dose-dependent melanin and tyrosinase inhibitory activity which was significantly stronger than control drug Arbutin. The study suggests that *C. amada* rhizome could be potential candidate as natural whitening agents in the cosmetic industry [75].

Platelet Aggregation Inhibitory Activity

The acetone and ethyl acetate extracts were reported to show dose-dependent platelet inhibitory activity [17, 76].

Biopesticide Activity

According to previous research, *C. amada* is a very efficient insecticide or pesticide. It displayed complete adult mortality and a decrease in oviposition, even at a concentration as low as 0.5%. The essential oils exhibited complete repellent effect [76]. Furthermore, *C. amada* demonstrated a high level of efficacy in suppressing the formation of the F1 generation of weevils, as reported by Ahmad and Ahmad in 1991 [77].

Brine-Shrimp Lethal Activity

The aqueous extract derived from the rhizomes of mango ginger exhibited deadly effect against brine-shrimp with lethality value (LC_{50} = 6,600 μg, 24 h) [78].

CNS Depressant and Analgesic Activity

The ethanol fraction of mango ginger rhizome demonstrated central nervous system depressive and analgesic effects [79]. The active percentage exhibited a decrease in exploratory activity, resulting in a reduction in barbiturate sleeping time, which indicates its central nervous system depressive function. Additionally, it demonstrated a decrease in tail-flick response and carrageenan-induced inflammation, suggesting possible pain-relieving and anti-inflammatory effects [76].

INDUSTRIAL APPLICATION

C. amada offers a wide range of industrial applications primarily driven by its aromatic compounds and medicinal properties, making it a versatile and valuable plant species in various sectors. The rhizomes contain bioactive compounds which have antioxidant, anti-inflammatory, and antimicrobial properties. Thus, this species can be a valuable in pharmaceutical sector like turmeric (*Curcuma longa*). *C. amada* rhizome has a distinct aroma which makes them a suitable candidate for use in perfumes and scented products. The antioxidant properties of *C. amada* make it a potential ingredient in cosmetic formulations. It may be used in creams, lotions, and facial masks due to its anti-inflammatory and skin-brightening effects. The industrial application of this potential medicinal plant has not been explored completely due to the lack of information on chemical compounds present and clinical trials.

CONCLUSION

The *Curcuma amada* plant is a remarkable medicinal herb that has been widely used as both a food and a medication in various parts of the world for a considerable period. This review provides a comprehensive account of the historical background of *C. amada*, its traditional uses, and its pharmacological properties. Moreover, the phytoconstituents found in *C. amada* have been associated with a diverse array of therapeutic benefits. Further studies are needed to isolate and characterize the chemical compounds to properly understand its industrial application.

Declaration of Interest

Authors declare no conflict of interest.

Acknowledgment

The authors would like to thank Vice-chancellor of JIIT for providing infrastructural facility for conducting this research and for fellowship to NB.

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