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Review on Phytopharmacological Activity of Curcuma amada Roxb. (Mango ginger)

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ABSTRACT

Plants have been an essential part of our daily lives since early advancement. Since prehistoric times, they've been found and employed in traditional medicine. The plant has been used as a medication for diseases and disorders. *Curcuma amada* Roxb. (Mango ginger) of the family Zingiberaceae belongs to the genus *Curcuma*, a beneficial plant in the indigenous system of medicine. It has a significant role in food as well as in pharmaceuticals. Some of its outstanding medical characteristics, including antioxidant, antiviral, antibacterial and anti-inflammatory properties, have been reported. Dermatological issues like eczema, itching, and digestive problems are treated with rhizomes. The plant parts are rich in starch, phenolic acids, curcuminoids, volatile oils, minerals, vitamins and phytoconstituents like labdane diterpene dialdehyde, amadaldehyde, zederone, amadannulen, difurocumenonol. *C. amada* is used in Ayurveda and Unani medical systems as an aphrodisiac, expectorant, appetizer, diuretic, emollient, antipyretic as well as to treat asthma, skin ailments, itching, biliousness, bronchitis, hiccough, and inflammation caused by accidents. This research focused on the main active ingredients, their biological activities and therapeutic capabilities, traditional use and proven pharmacological aspects that may be important from a pharmacological standpoint.

Keywords: Ayurveda; *Curcuma amada*; Ethnobotanical; Phytoconstituents; Pharmacology

1. INTRODUCTION

According to the World Health Organization (WHO) Global Health Estimates (GHE) for 2019, NCDs (Noncommunicable diseases) accounted for 74 % of global mortality. Seven out of the top ten leading causes of death worldwide are noncommunicable diseases, up from just four in 2000. In recent years, non-communicable diseases (NCDs), lifestyle problems, and chronic illnesses with multidrug-resistant conditions have increased the popularity of alternative medicinal systems, including Ayurveda, Homeopathy, Siddha, and Unani. WHO recently conducted a conference at the Ministry of AYUSH to discuss the development of standardized terminologies and benchmark papers for traditional medicine. WHO will develop standards for Ayurveda, Panchakarma, and Unani medicine.[1]

The WHO Traditional Medicine Strategy 2014-2023 aims to improve traditional medicine's safety, quality, and efficacy by regulating it and promoting its safe and effective use. Currently, numerous possible natural antibiotic sources have been exploited for newly borne infectious diseases, which are losing their significance. The whole spice *C. amada* is morphologically similar to ginger (Zingiber officinale) with a fresh mango flavour.[2] Linnaeus named Curcuma in his Species Plantarum in 1753. The name is most likely derived from 'Kurkum,' which means yellow.[2]

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Plant essential oils are widely used as natural alternatives to harmful chemical biocides and antibiotics. Mango ginger, or *Curcuma amada*, is extensively used in various aromatics industries because of its strong mango-like aroma.[3] The mango aroma and taste make it desirable for use as a fragrance ingredient and in other industrial and therapeutic applications. Mangiferin and 2-3 pentanediol were compounds identified from the plant's rhizome extract. In addition, the plant is said to have antiobesity, antimicrobial, anticancer, and anti-diabetic effects.[4] The alkaloids, terpenoids, flavonoids, and phenylpropanoids found in the rhizome make it the most valuable portion of the plant. It has been employed in treating various medical issues, including as a laxative, appetiser, diuretic, aphrodisiac, emollient, antipyretic, and expectorant, in Ayurveda and Unani medicine. Due to its high nutritional and pharmacological importance, research into mango ginger's phytochemical composition has gained momentum in recent years.[5] This review aimed to assess a lot of evidence available on the plant's morphological characteristics, background and cultivation, production, range of its chemical composition, pharmacological activity, and many potential uses.

2. PLANT DESCRIPTION

C.amada belongs to the family Zingiberaceae, a perennial, rhizomatous, fragrant herb. This family has 70-80 species of rhizomatous annual or perennial herbs

(Fig. 1).[2] Originally from the Indo-Malayan region, the genus has spread throughout Asia, Africa, and Australia.[2,6] Curcuminoids, volatile essential oils, carbohydrates, phenolic acids, and terpenoids such as diflurocumenonol, amadaldehyde, and amadannulen can all be found in mango ginger.[7] This species of the *Curcuma* family is essential for its medicinal and biological uses. Pickles are the most common application of mango ginger rhizome.[2,7] Although it looks like ginger, the monsoon season in India brings a different spice to the marketplaces (Table 1).[2] Mango ginger does well in moist but well-drained soil. The sandy loam soils are also ideal for its growth. It can be cultivated in either full sun or partial shade because of its adaptability. The plant works well in a crop rotation that also includes vegetables. Rainfall of at least 1500 millimetres yearly in a hot, humid tropical climate is required. Mango ginger requires a lot of water in its development phase. The required temperature range is between 2°C and 3°C. Mango ginger parts have been collected from many areas and are now preserved in numerous herbariums globally and nationally for authorization (Fig. 2).[2,3,4,5]

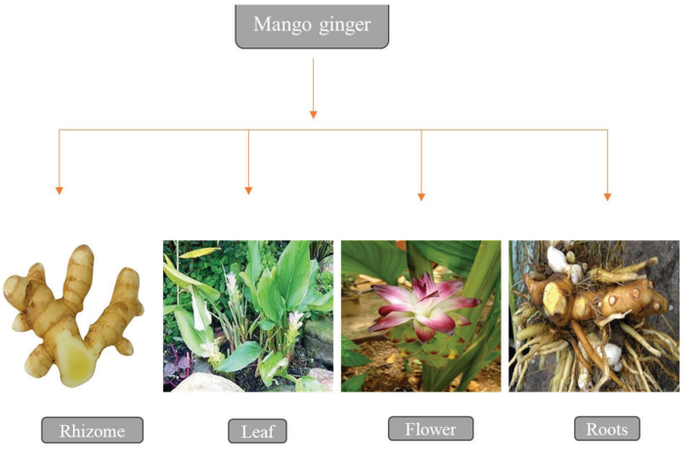

Figure 1. Morphological traits of Mango ginger

Table 1. Morphological and anatomical characteristic features of the plant

Habit	Upright, Perennial, Rhizomatous herb grows up to 80cm to 1M tall.[4,7]
Root	This species has fleshy, buff-coloured rhizomes between 5 and 10 centimetres long and 2 to 5 centimetres wide. They are divided into nodes and internodes. Sympodial branching occurs on the rhizomes.
Leaves	Long, radical, sheathed, lanceolate, oblong, petiolate, and tufts of leaves. Each plant has 5 to 6 leaves, dark green on top and pale green underneath.
Flower	Unisexual, sterile, and yields no viable seeds. 2-4 cm long, pink, flowering throughout the year, and terminal or axillary pseudo racemes.
Fruit	Oblong pod, Thin septate, pilose, wrinkled.

Figure 2. Mango ginger plant specimens collected for the herbarium (Herbarium of the Regional research laboratory, Jammu and Kashmir)

3. ORIGIN AND DISTRIBUTION

They spread over Asia, Africa, and Australia from the Indo-Malayan region.[2] It is found in West Bengal and is grown in Karnataka, Gujarat, Uttar Pradesh, Kerala, Tamil Nadu, and the Northeastern states of India. An indigenous to the Indian subcontinent, it is now widely farmed in the humid subtropics of South East Asia and the Indian subcontinent and throughout portions of Africa.[8]

4. VARIETIES OF *CURCUMA* SPECIES

C. mangga and *C. amada* are the same species; however, others consider them separate species. *C. mangga* is native to southern India, but *C. amada* is native to eastern.[9] The varieties and uses of *Curcuma* species are given below:

4.1 *C. manga*

It is a variety of the *Curcuma* family in southern India. In Malaysia, it's known as Temu pauh because when the rhizome is sliced, it emits an aroma that smells like mango. It has been used primarily in alternative and complementary medicine for centuries. For example, the rhizomes can be used to relieve stomach and chest pain, and they can also aid in the recovery of the uterus after childbirth. It can also soothe itchy, red areas on the skin and bring down a high-temperature fever.[10]

4.2 *C. zedoaria*

Originally from Southeast Asia and South Asia, this plant can be found in Florida, the United States. Its rhizome has a white interior and a fragrance of mango. It's pounded into a powder and used to produce white curry pastes in Indonesia, although it's more commonly used fresh or pickled in India. Thai cuisine is served raw in salads and chopped into thin strips. In India,

it's common to use it to season dals and chutneys. The Vibrant is occasionally brought indoors to brighten the decor. Wounds, menstruation abnormalities, and ulcers are just some skin ailments the herb has long been used to cure.[10]

4.3 *C. brog*

It is found in the northeast part of India. Its rhizome is used for cooking purposes as well as for preparing cosmetics products.[10]

4.4 *C. caesia*

The colour of the rhizome is bluish-black; hence, it is known as Black Tumeric or Black Zedoary. It is found native to northern India.[11]

4.5 *C. haritha*

It is an aromatic rhizomatous herb with sessile tubers and a big rhizome with a yellowish-grey interior. It can be found in India's southern Western Ghats.[11]

4.6 *C. sylvatica*

It is distributed in India and Java. It can be found throughout Kerala and the northeastern part of India. The colour of the rhizome is white. It has an aroma of mango and is slightly bitter.[12]

4.7 *C. malabarica*

It is widely farmed in South India. Only the starch in these tubers is used.[13]

4.8 *C. aromatica*

It can be found in China, Japan, and India and grows in tropical and subtropical climates. Traditional medicine uses it as a flavouring and colouring agent.[13]

4.9 *C. raktakanta*

It is distributed in Bangladesh, China, India, Malaya, Cambodia, Myanmar and Thailand. In India, it is found in Kerala and the Northeastern region.[13]

4.10 *Curcuma longa*

Curcuma longa (Turmeric), one of the most widely used *Curcuma* species, has been used for centuries to treat various ailments. In traditional Indian medicine, the rhizome is often used as a first-line remedy for coughs and colds. The flavour of the rhizome is both hot and aromatic. Curcumin, the active element in turmeric, has been called the "holy grail" for its numerous health benefits. Antioxidant, anti-diabetic, anti-cancer, anti-microbial, and anti-inflammatory are just a few of curcumin's many benefits. Numerous other important phytochemicals can be found in turmeric, including alkaloids, terpenoids, flavonoids, tannins, saponin, steroids, phenolic compounds, phytosterols, glycosides, carbohydrates, proteins, amino acids and many more in the leaf and rhizome.[14]

5. CULTIVATION

It thrives in hot, rainy, tropical climates. Growing conditions in manure wetlands are excellent because the soil is sandy and loamy and drains swiftly. As such, it can function as a part of a multi-cropping system. Sunlight is critical for plant development. Mango ginger thrives in hot, humid climates with at least 1500 millimetres of annual precipitation for optimal growth. The required temperature range is between 20 and 30 ˚C. They thrive in tropical forests with plenty of coconut palms. Healthy rhizomes or seeds can be used for planting.[14,15]

5.1 Preparation of land

Fertile manure wetlands (soil), like sandy, loamy soil that drains properly, should be established on the land. The best time to do it is between February and March when pre-monsoon rains tend to fall. A ground bed should be 1.2 m long, 25 cm wide, and 40 cm apart. Forests of coconut palms are ideal for their cultivation.[16]

5.2 Seed material and varieties

Well-developed, matured, healthy, and disease-free mother rhizome or seed is selected, weighing about 15-20g.[4,16]

5.3 Season and method of planting

Plant in April, as pre-monsoon precipitation begins. Small pits in the beds should be prepared with a spacing of 25 cm in height and 1m long, and at a depth of about 4-5 cm, the temperature range of 20 °C to 30 °C must be maintained. Use a 1500 kg ha-1 seeding rate.[16]

5.4 Manuring

Applying 15kgs of organic fertilizer, including chicken, cow dung powder, goat manure, and compost, to 1% of the land. Organic fertilizers, 650 grams of superphosphate, 200 grams of potash, and 40 grams of urea are added after a month of planting if the inorganic farming method is used. After two months, the urea and potash are re-added at 20 g and 200 g, respectively.[4,16]

5.5 Mulching

A layer of mulch should follow planting with green leaves and repeat the mulching procedure every 50 days with the same quantity of green leaves.[14,16]

6. AFTER CULTIVATION

Within 3-4 weeks of culture, the rhizomes begin to germinate. Removal of weeds should continue after planting. Six months after planting, mango ginger will be ready to harvest in a few weeks. The stem, like ginger, progressively wilts. The rhizomes can be carefully dug up without being cut into pieces by the spade. From 1% of the field, up to 40 kg can be harvested.[14,16]

7. PLANT PROTECTION

There are a few obstacles to growing mango ginger

because of pests and illnesses. Spots on both sides of leaves are a clear indication of leaf spots.[17] Compared to ginger and turmeric plantations, regular monitoring is required, free of pests and illnesses. However, the attack of the shoot borer (*Conogethes punctiferalis*) can cause damage to the crop. The main symptom is the appearance of a dead heart in the field. Pests can be controlled by removing and burning the dead souls that contain larvae. Spray dimethoate or quinalphos at 0.05 per cent as an alternative technique.[17]

8. WORLDWIDE PRODUCTION RATE

More than 80 per cent of the mango ginger produced worldwide originates in India, according to research from the APEDA, the world's top turmeric producer. As per the report published by the APEDA, apart from India, China contributes about 8%, Myanmar with 4%, Nigeria with 3%, and Bangladesh with 3% shares in total production worldwide.[13]

9. STATE-WISE PRODUCTION

The southern states of Tamil Nadu and Andhra Pradesh produce the majority of mango ginger in the country, accounting for more than 80% of the total output. Andhra Pradesh is India's largest producer, accounting for more than 60% of the country, and Tamil Nadu is the second-largest producer in India, contributing 17%. Odisha produces 7%, West Bengal and Karnataka have 3%, Gujarat produces 2%, and Kerala makes 1%.[15]

10. SANSKRIT SHLOKA DEPICTING THE BENEFITS OF MANGO GINGER

As medicines, dyes, and spices, many species in this genus are highly sought-after by the food industry. In addition, its rhizomes provide other health advantages, including biliousness, itching, skin issues, Asthma, and inflammation caused by injuries.[18] Mango ginger has been used medicinally for centuries. Mango ginger's potential for commercial success comes from its use in many different ways, including as a vegetable, a spice, a condiment, and medication. Itching, skin disorders, and respiratory issues are all treated with mango ginger's traditional/ natural remedies. Sustainable production, preservation, and plant usage are all important, and scientists should do more to provide evidence-based data to back up its traditional applications.[17]

11. EFFECTS OF AYURVEDIC MEDICINE ON THE HUMAN BODY

It is used in Ayurveda to treat skin irritation, hiccups, cough, wounds, fever, inflammations, earache, respiratory sickness, and tri-dosha vitiation.[18] The rhizomes, which can be applied topically to reduce inflammation following an injury, provide a cooling effect. It treats contusions and sprains and has carminative and stomachic properties. Mango ginger has various human health benefits, including improved nutrition and the potential for illness treatment. Mango ginger rhizome contains curcuminoids with anti-inflammatory, anti-mutagen, anti-oxidant, anti-microbial, and detoxifying activities. Camphor, another ingredient in mango ginger, stimulates and improves the performance of the digestive system.[17]

12. NUTRITIONAL COMPOSITION

C. amada is a nutrient-dense plant species that contain sugars, starch, fibres, essential oils, proteins, amino acids, minerals, and vitamins like Thiamine, Niacin, Pyridoxine, Vitamin A, Vitamin C, Vitamin E and Riboflavin.[19, 20, 21] The essential oil composition of the rhizome and leaf extract of plant species is (E)-β-Ocimene (2.61%), Borneol (1.87%), α-Longipinene (14.8%), Camphene Hydrate (1.25%), Guaia-6,9-Diene (19.8%), Thymol (4.9%), Myrcene (88.84%), α-Guaiene (14.5%), Isoborneol (7.30%), Curzerenone (9.53%), Camphor (17.90%), Camphene (3.57%), Epi-Curzerenone (10.76%), (Z)-β-Farnesene (21.9 %), Camphor (5.5%), Curzerene (3.95%), Furanogermenone (1.77%), and β-Pinene (3.74%).[22, 23]

Acetone extract of *C. amada* mostly consists of curcumin, bisdemethoxycurcumin, and bisdemethoxy curcumin, all of which are quite well-known. Other pharmacological studies on the rhizome part of the plant have revealed the existence of additional chemicals, including Labdane diterpene dialdehyde, amadaldehyde, zederone, Amadannulen, difurocumenonol, which are thought to be responsible for the antiplatelet, antioxidant, and antibacterial properties.[18, 24, 25, 26] Further, it has free phenolic components such as ferulic acid (24%), cinnamic acid (15%), caffeic acid (14%), gentisic acid (12%), gallic acid (5%), protocatechuic acid (4%), syringic acid (2%) and P-coumaric acid (1%) (Table 2).[2, 27]

13. PHYTOCHEMICAL CONTENT

Different phytochemicals are present in the leaf and rhizome of *C. amada* (Table 3). Extracts made with chloroform, ethanol, methanol and water contain coumarin and cardiac glycosides. Extracts made with either ethanol or methanol, as well as water, contain some phytosterol, tannin, alkaloids, gum chloroform, terpenoids and flavonoids. Both ethanol and methanol extracts contain ellagic acid, reducing sugar, protein and anthraquinone.[24-27] Phytochemical analyses showed that *C. amada* extracts included more flavonoids, phenols, tannins, and saponins than *C. karnatakensis*.[15] The phytochemical study, both qualitative and quantitative, showed that the methanolic extract had a high concentration of phytochemicals such as carbohydrates, protein, alkaloids, flavonoids, tannins, phenolics, saponins, and fibre. The findings of the fluorescence analysis verified the existence of these phytochemicals as well. Stretching vibrations associated with functional groups such as alkanes, alkenes, alcohols, phenols, aliphatic amines, carboxylic and aromatics acids were reported by FTIR.[28]

14. PHARMACOLOGICAL ACTIVITIES

This analysis of the phytoconstituents and biomedical

Table 2. Nutritional components screening of Mango ginger

Plant	Chemical Constituents				
Parts	Nutrition	Essential Oil	Curcuminoids	Bioactive compounds	Phenolic compounds
Rhizome and Leaf	Sugars, Starch, Fibres, Iron, Proteins, Amino Acids, Minerals like Calcium, Potassium, Phosphorous, Sodium, Copper, Chromium, Nitrogen, Magnesium, Molybdenum, Manganese, Potassium, Sulfur, Sodium, Manganese, Zinc, as well as Vitamins like Thiamine, Niacin, Pyridoxine, Riboflavin, Vitamin A, Vitamin E, and Vitamin C	(E)-β-Ocimene, Borneol, α-Longipinene, Camphene Hydrate, Guaia-6,9-Diene, Thymol, Myrcene, α-Guaiene, Isoborneol, Curzerenone, Camphor, Camphene, Epi-Curzerenone, (Z)-β-Farnesene, Camphor, Curzerene, Furanogermenone, and β-Pinene	Curcumin, Bismethoxycurcumin, Bisdemethoxycurcumin	Labdane diterpene dialdehyde, amadaldehyde, zederone, Amadannulen, difurocumenonol	Caffeic, Ferulic, Gentisic, P-Coumaric acid, Gallic, Syringic, Cinnamic, Protocatechuic

applications of *Curcuma amada* suggests that the plant has medicinal potential for treating a wide range of diseases and disorders. In addition, this study provides potential supporting evidence for the bioactive properties and traditional use of mango ginger rhizome in Ayurveda and other healing modalities (Table 4).

14.1 Antioxidant Activity

Antioxidants are well-known for their effectiveness in treating skin-related issues. It aids in body detoxification and enhances skin tone.[29] Its leaves and rhizomes may effectively generate nitric oxide and superoxide in vitro, with methanolic extracts producing the most, followed by chloroform and aqueous extracts. Methanol extracts from leaves and rhizomes were tested for their antioxidant properties using the β-carotene bleaching method.[30, 31, 32]

14.2 Antimicrobial Activity

Escherichia coli, Bacillus subtilis, and *Staphylococcus aureus* are all susceptible to the antibacterial effects of mango ginger's aqueous and organic solvent extracts (Table 5).24 Antibacterial properties have been demonstrated for both free and bound phenolics, i.e., cinnamic and ferulic acids effectively inhibit H+, K+-ATPase activity, and *Helicobacter pylori* growth.[27, 33] It has been found that extracts such as chloroform and the like are particularly effective against bacteria such as Bacillus subtilis, *Listeria monocytogenes*, Micrococcus luteus, Enterococcus fecalis, *Staphylococcus aureus*, *Salmonella typhi*.[27] *Bacillus cereus*, *Staphylococcus aureus*, Bacillus subtilis, Micrococcus luteus, and Listeria monocytogenes can all be killed by hexane, acetone, ethyl acetate, chloroform, and methanol extracts.[18] Labdane diterpene dialdehyde compound exhibited antitubercular activity against Mycobacterium tuberculosis. The antifungal properties of volatile rhizome oil have been demonstrated.[2] Involved volatile oils are mainly composed of myrcene (4.6 per cent) and pinene (80.5%), which are responsible for their antifungal activity against a wide variety of fungi, including *Curvularia palliscens, Aspergillus niger,* Aspergillus terreus, Fusarium moniliforme, and *Fusarium falcatum*.[2, 34] Zederone and furanodienone are antifungal chemicals with dose-dependent antifungal action against Fusarium solani sensu lato.[35, 36]

14.3 Anti-inflammatory Activity

C. amada has an anti-inflammatory action that is helpful in the treatment of inflammations caused due to injury, liver inflammation, arthritis, and rheumatism.[29] Chemicals with hydroxyl, ester, carbonyl, and olefin functional groups found in ethyl alcohol extract cause inflammation in albino rats when administered chronically or acutely.[2] R. communis methanolic extract had the maximum total phenolic content, while the ethanolic extract of *C. amada* had the highest flavonoid content.[37] There was the greatest anti-inflammatory benefit from the hexane, deep-fried in coconut oil (DF) mango ginger extract, followed by the 100% essential oil and the 50% mango ginger essential oil.[38]

14.4 Anti-cancer Property

The extract of *C. amada* shows the anti-cancer property of different solvents. It has been reported to show anti-cancer properties against human large-cell lung cancer (NCI-H460) cells and human small-cell lung carcinoma cells (A-549). Compared to normal cells, all extracts had higher toxicity for cancer cells. Compared to temozolomide, Curcumin, and Turmeric, etoposide, a supercritical CO2 extract of *C. amada*, exhibited more potent cytotoxicity in human glioblastoma (U-87MG) cell lines. Methanol extracted from leaves and rhizomes is

an anti-cancer against breast cancer and causes cell death in MDA MB 231 and MCF-7 breast cancer lines. Anti-cancer effects are also found in terpenoids and steroid compounds.[39]

14.5 Cytotoxicity

More significant toxicity against cancer cells was found in extracts of mango ginger in hexane, chloroform, ethyl acetate, acetone, and methanol solvents. Ether acetate extract was the most poisonous, followed by chloroform and hexane in order of decreasing potency. Several mango ginger extracts' cytotoxicity results have shown that the extracts are less harmful to standard cell lines.[2] The ethanolic rhizome extract (CAEREt) of *C. amada* was highly cytotoxic to the HeLa cell strain. Phytocompound-rich rhizome extract was found to have improved antioxidant and cytotoxicity activities.[40]

14.6 Antiallergic Activity

It is reported to be used to make a variety of valuable herbals.[2],[41]

14.7 Biopesticide Activity

As per the report of several studies, C.amada is one of the highly effective insecticides or pesticides. Even at 0.5 per cent concentration, it showed 100% adult mortality and decreased oviposition. Its essential oils entirely deter all other insects.[2,42] Biochemical research on these promising oils could produce a variety of valuable pesticides that will benefit future generations. It took 45 days for the insect death rate to reach 100% at 1% mortality levels.[2,35]

14.8 Hypotriglyceridemic Activity

Hypertriglyceridemia activity in Tritoninduced hyperlipidemic rats has been shown by extracts of C.amada, which has immense significance for liver synthesis and blood clearance.[2,43]

14.9 Brine-shrimp Lethal Activity

Brine shrimp *(Artemia salina) C. amada* rhizomes' water extract has shown lethal activity.[44] Lethality was determined using a graph showing the percentage of shrimp killed against the number of extracts (LC50=6,600g, 24 h). The extract's attention was directly related to its lethality.[2,43]

14.10 Analgesic and depressive activity in the central nervous system

A portion of rhizome ethanol extract showed CNS depressive and analgesic effects.[45] Barbiturate sleeping time exploratory activity was reduced in the active fraction, indicating CNS depressant activity. Antinociceptive and antiphlogistic actions have diminished acetic acid-induced writhing, tail-flick response, and carrageenan-induced inflammation.[2]

14.11 Antitubercular and Inhibitory Action of Enterokinase

Both inhibitory and anti-inflammatory properties of enterokinase have been discovered in mango ginger[46] and antitubercular activity. Lambda-8 (17),12-diene-15,16-dial, and modified analogues of the labdane-type diterpenoid, lambda-8 (17),12-diene-15,16-dial, exhibit antitubercular effects.[47]

Table 3. Phytochemical screening of *C. amada*

Sl. No.	Phytochemicals	Rhizome extract	References
1	Cardiac glycosides	Chloroform, Ethanol, Methanol, Distilled water	15
2	Glycosides	Ethanol	18
3	Leucoanthocyanin	-	
4	Phytosterol	Ethanol, Methanol, Distilled water	11
5	Ellagic acid	Ethanol, Methanol	11
6	Reducing sugar	Aqueous, Ethanol	
7	Anthraquinone	Ethanol, Methanol	21
8	Steroids	-	12
9	Chalcones	-	
10	Volatile oils	-	
11	Terpenoids	-	
12	Saponin	Distilled water	12
13	Flavonoids	Ethanol, methanol,	12
14	Coumarin Chloroform,	Ethanol, Methanol, Distilled water	21
15	Phenolic compounds	-	48
16	Sterols	-	
17	Tannins	Ethanol, Methanol, Distilled water	21
18	Terpenoid	Chloroform, Ethanol, Methanol, Distilled water	48
19	Alkaloids	Ethanol, Methanol, Distilled water	49
20	Protein	Ethanol, Methanol	
21	Ligands	Ethanol, Distilled water	49
22	Phlobatannin	Ethanol, Methanol, Distilled water	

23	Cysteine	-	
24	Emodins	-	
25	Gum Chloroform	Ethanol, Methanol, Distilled water	21

15. APPLICATIONS OF C.AMADA

Due to its high antioxidant capacity and particular mineral components, *C. amada* offers positive health advantages with only a small amount of consumption.

15.1 Food Processing

The aroma of raw mango gives its name in addition to flavourings, teas, and unusual foods. Salads, for example, often feature it. It can also produce fabric and starch to lower the sugar content in liquids. In addition, pickling spices often include mango ginger.[2]

15.2 Medicines

The parts are used as medicines as it has many curing and biological activities. Medical uses for the rhizomes include treating stomach and chest pains and helping the womb heal after childbirth.[58] It is often used as a remedy for coughs and colds. It's useful for treating asthma and bronchitis, too. The phenolic chemicals it contains make it useful for reducing airway irritation.[59] Liver-related disorders can be treated with *C. amada* because of the plant's curative capabilities, which include regulating fatty acid metabolic rate and decreasing cholesterol.[60]

In addition to lowering cholesterol levels and helping people maintain a healthy weight, treating obesity can prevent further weight gain. It also inhibits the production of fat.[61] In addition to its other benefits, this plant aids in detoxification by reducing gas, stimulating hunger, and strengthening digestion. It also treats constipation, increases digestive strength, and stimulates hunger.[62]

Table 4. Pharmacological activities of *C.amada*

Sl. No.	Different extracts	Plant parts	Biological activities	Chemical constituents	Medicinal importance	References
1	Aqueous and organic solvent	Rhizomes	Antibacterial activity	Difurocumenonol, amadannulen flavonoids, Cinnamic and ferulic acids	Cinnamic and ferulic acids found in mango ginger suppress the H+, K+-ATPase, and growth inhibition of H.pylori.	15
2	Methanol	Leaf & Rhizomes	Antioxidant activity	Curcumins, curcuminoid, phenolic compounds, or flavonoid components	Methanol extract of the leaves showed maximum antioxidant activity compared to rhizome extract and helped detoxify the body.	18
3	-	Rhizomes	Antifungal activity	myrcene and pinene (volatile compounds), zederone, and furanodienone	Volatile oils in the rhizome show antifungal properties	15
4	Ethanolic	Rhizomes	Antimicrobial activity	Difurocumenonol, curcuminoids	Antibacterial efficacy of the difurocumenonol compound against gram-negative and gram-positive bacteria	50
5	Ethyl acetate, acetone, and methanol	Rhizomes	-	Amadaldehyde	Ethyl acetate extract showed anti-cancer properties	48
6	Methanol	Leaves	Anticancer	Terpenoids and steroids compounds	Breast cancer cell lines MDA MB 231 and MCF-7 die faster when treated with it because it has anti-cancer capabilities.	48
7	-	Rhizomes	Anti-allergy activity	-	Antiallergic properties in Herbal preparation.	18
8	-	Rhizomes	Biopesticide activity	Essential oils	It is one of the highly effective insecticides or pesticides.	48

9	Aqueous and methanolic	Rhizomes	Hypotriglyceridemic activity	-	Tridon-induced hyperlipidemic rats experiment shows hypotriglyceridemic activity.	18
10	Aqueous	Rhizomes	Brine shrimp's lethal activity	-	It was found to be harmful to brine shrimp. It demonstrated the plant's bioactivity.	18
11	Ethanol	Rhizomes	Analgesic and depressive activity in the central nervous system	-	Barbiturate sleeping time exploratory activity was reduced in the active fraction, indicating CNS depressant activity	50
12	-	Rhizomes	Enterokinase inhibitory activity	-	It possesses Enterokinase activity	48
13	-	Rhizomes	Cholesterol-lowering activity	Curcumin compound	It has a cholesterol-lowering activity	18
14	-	Rhizomes	Anthelmintic Activity	Flavonoids, carbohydrates, glycosides, saponins, phytosterols, resins compounds	Against anthelmintic activity	48
15	Chloroform	Rhizomes	Antitubercular activity	Labdane diterpene dialdehyde	Antitubercular solid activity against Mycobacterium tuberculosis.	18
16	Oil extraction	Rhizomes	Antispermatogenic activity	-	Extracts have the potential to get better motility, sperm count, and testosterone levels.	48
17	Ethyl acetate extract and acetone	Rhizomes	Platelet aggregation inhibitory activity	Phenolic content, Amadaldehyde	The high phenolic content and concentration dependence of ethyl acetate, acetone, and methanol extracts platelet aggregation inhibitory effect appears to be due to their high phenolic content	18
18	-	Rhizomes	Wounds, cuts, itching	Phenolic compounds	The extract used to treat healing wounds, scratche	48
19	-	Rhizomes	Skin diseases	-	Rhizome pastes cure skin diseases	18

15.3 Relieves Pain

It is a soothing agent that helps reduce pain in our bodies. Its oil is prepared to massage the body, which helps relieve pain. Calming properties aid in relieving physical discomfort.[58]

15.4 Treats Skin Diseases

It has antibacterial and antioxidant properties. It improves skin tones and complexion and helps clear acne and other skin problems. It helps treat skin conditions and is also present in many cosmetics. It aids in the elimination of toxins from the body and the improvement of skin tone, and the removal of acne. It is an excellent treatment for skin rashes and sunburn when applied externally. It can be used externally with milk to achieve fairer, blemish-free skin.[57] This material's great antibacterial and anti-inflammatory properties make it ideal for fighting acne. It also reduces the inflammation and pain associated with pustule acne.[63] *C. amada* powerful antioxidant properties prevent cellular damage to the skin. The skin's elasticity is enhanced by this miraculous cure, giving it a more young, supple, and soft appearance.[62] It soothes irritated skin and lessens itching.[64]

15.5 Skin Whitening

It is one of the most effective ingredients in skin lightening and whitening treatments. It is also supposed to lighten dark spots, reduce hyperpigmentation, and balance skin tone and complexion. As a result, the tradition of applying Haldi is observed at several Hindu festivals

Table 5. Antimicrobial activities of *C. amada*

Sl. No.	Type of extract	Microbes	References
1	Acetone	*L.monocytogenes, M.luteus*	15
2	Rhizome dichloromethane (DCM) and ethanol	*S.pyogenes, S.aureus, P.aeruginosa, E.coli*	51
3	AgNPs	*S. aureus, B.cereus, K.pneumonia, P.aeruginosa, E.coli, C.albicus.*	52
4	Aqueous	*B.Subtilis, E.coli, S. aureus*	53
5	Rhizome	*S. aureus, E. coli, C.albicans*	54
6	Hexane, chloroform-methanol, and essential oil	*R.solanacearum*	55
7	Essential oil	*F.moniliforme, A.niger, C.palliscens, A.terreus, F.falcatum*	54
8	Rhizome	*P.mirabilis, S.dysenteriae, C.albicans, S.aureus, P.aeruginosa, S.typhi, C.trophicali.*	
9	Phenolic fractions	*H.pylori*	56
10	Volatile oil	*F. falcatum, A.niger, F.moniliforme, A.terreus, C.palliscens.*	57
11	Chloroform	*B. subtilis, E.fecalis, S.aureus, B.cereus, L.monocytogenes, M.luteus, S.typhi*	
12	Essential oil	*B.cereus K.pneumoniae, S.aureus, S.typhi, E.fecalis, B.subtilis, P.aeruginosa, M.luteus, Y.enterocolitica, P.mirabilis, E.aerogenes, E.coli and L.monocytogenes.*	49

throughout India.[57] It also promotes blood circulation, which helps to promote the appearance of healthy and glowing skin. Furthermore, it is applied to pigmented skin and effectively prevents melanin development in new skin cells, making the skin look brighter.[65]

16. CONCLUSION

Plant-based medicines are a viable alternative to synthetic pharmaceuticals because of their high prices and adverse effects. *C. amada*, a perennial, rhizomatous, aromatic herb with immense potential, has remained unexplored for its health benefits because it could be utilized as an alternative source. The health advantages have been clinically proven in Ayurvedic and other traditional medicines. However, we must now understand these elements' structure-activity linkages and pharmacological activity more than ever. More active principles can be synthesized to create pharmacological compounds with health benefits.

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