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A COMPREHENSIVE REVIEW OF PHYTOCHEMICAL INVESTIGATIONS AND PHARMACOLOGICAL POTENTIAL OF CURCUMA AMADA (MANGO GINGER), A PROMISING MEMEBER OF THE "ZINGIBERACEAE FAMILY"

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ABSTRACT

Mango ginger (Curcuma amada), an annual plant from the Zingiberaceae family, is notable for its unique mango-flavored rhizomes and significant medicinal value. Traditionally used in culinary applications, particularly in pickles, it also holds a prominent place in Ayurvedic and Unani medicine as an appetizer, antipyretic, aphrodisiac, diuretic, and treatment for various ailments such as skin diseases, bronchitis, asthma, and inflammation. The rhizomes exhibit a wide range of biological activities, including antioxidant, antibacterial, antifungal, anti-inflammatory, cytotoxic, and analgesic effects. Chemically, *C. amada* is rich in starch, phenolic acids, curcuminoids, and volatile oils, with key terpenoids like difurocumenonol, amadannulen, and amadaldehyde. GC/MS analysis revealed essential oil components such as α-pinene, p-cymene, camphor, and β-curcumene. Essential oils extracted through various methods—hydrodistillation, steam distillation, microwave-assisted extraction, and ultrasound-assisted extraction—demonstrated notable antibacterial, anti-inflammatory, larvicidal, and insecticidal properties, with UAE and MAE showing enhanced antibacterial efficacy.

KEYWORDS: Mango ginger, *Curcuma amada*, essential oil, traditional medicine, volatile compounds, extraction methods, bioactive compounds.

1. INTRODUCTION

Curcuma amada, commonly known as mango ginger, belongs to the genus *Curcuma* and the family Zingiberaceae. It is widely used in the food industry and traditional medicine. The *Curcuma* genus comprises approximately 60 to 100 species found across various regions, including Southeast Asia, the Indian subcontinent, tropical Africa, southern China, New Guinea, northern Australia, and the Americas. This diversity has led to uncertainty in its taxonomy. Notable species in the genus include *C. longa* (turmeric), *C. aromatica* (kasturi turmeric), *C. zedoaria* (yellow zedoary), and *C. amada*. Due to the absence of sexual reproduction in *C. amada*, conventional breeding is challenging. The species exhibits high variability in rhizome color, flower structure, and aroma, resulting in chemical diversity. This variability is influenced by environmental factors such as soil nutrition, climate, and genotype. Mango ginger is known by different names across regions: "Ama Haldi" in India, "Amada" in Bangladesh, "Ama Adrak" in Pakistan, "Temu Mangga" in France, and "Mangoingwer" in Germany.

Several studies link its phytochemicals—such as polyphenols, flavonoids, and non-nutrient compounds—to antioxidant, anti-inflammatory, and therapeutic

properties. These compounds are used in pharmaceutical, cosmetic, and nutraceutical industries. While extensive research exists on *C. longa* and *Zingiber officinale*, *C. amada* remains underutilized despite its medicinal potential. Botanically, *C. amada* is a herbaceous perennial with an erect to semi-erect growth habit, growing 90–120 cm tall with a spacing of 15–22 cm. The rhizomes are large, branched, buff-colored externally, and pale yellow inside with a distinctive mango aroma. The plant has large, petiolated leaves—glabrous on the upper side and puberulous below. Inflorescence is lateral or central, hidden by leaf sheaths, with pale green to straw-colored bracts and rose-colored sterile bracts at the apex. Each bract bears 4–5 large flowers. Due to morphological similarities, *C. amada* is often difficult to distinguish from *C. longa* in herbarium specimens. Essential oil is primarily found in the rhizomes and fresh leaves, while dried parts yield minimal oil. The yield and composition of essential oils are influenced by origin, soil, climate, and plant variety. Overall, *C. amada* is morphologically and chemically diverse, making it an important but underexplored plant in the ginger family.

2. PLANT PROFILE

SYNONYMS: White turmeric, manga inji, aam haldi.
BIOLOGICAL SOURCE: The dried Rhizhome part of plant of *curcuma amada*.
FAMILY: Zingiberaceae.

GEOGRAPHICAL SOURCE: The geographical distribution of the genus from india to thailand, china, Malaysia, Indonesia and northen Australia, curcuma amada is found the wild in part of west bengal, and cultivated in Gujarat, uttar pradesh, kerala, karnataka, Tamil nadu and north eastern states.

Fig. 1: Mango Ginger.

2.1 Taxonomical Classification

- **Kingdom:** Plantae
- **Super division:** Spermatophyta
- **Division:** Magnoliophyta
- **Class:** Monocotyledonae
- **Order:** Zingiberales
- **Family:** Zingiberaceae
- **Genus:** Curcuma

2.2 Botany, Ecology & Morphology

Mango ginger is an herbaceous, stiff to semi-erect Plant. It is a rhizomatous perfumed herb with a leafy clump, 60–90 cm in height. The rhizome of the plant can grow up to 10-12 Inches long and has a pleasant smell of raw mango. The rhizome is bulky and pronged, with A buff-colored peripheral surface. The plant is available as well as grown all Over India in the temperate climate for its culinary and commercial value. The plant is a native Of Indonesia and China. The fleshy tissue color is Light to pale yellow, with a fragrance of green mango. Sessile tubers are broad, cylindrical, and plump. The leaves Are extensive, petiolate, and tapering at both ends. The lower Side of leaves is querulous whereas upper side of leaves is Glabrous. There is a spike/scape/ inflorescence with a Progression of strong, imbricated, pale-green or strawcolored fertile bracts.

These bracts are completed with a Coma or bunch of pale-purple or rose-colored unproductive Bracts, or leaves. The flowers are huge and elongated, with 4–5 flowers in respectively bract. Mango ginger requires Average water for growth. Over water affects its growth During development. 20°C is optimum temperature for seeds Germination of mango ginger. 15°C to 30°C temperature Range requires for growing stages of mango ginger. Warmth Temperature increases the growth of mango ginger. The Macronutrient fertilizer especially nitrogen contents-based Fertilizer increases the plant growth. Moreover, pH Parameter does not affect growth of mango ginger. 6 to 8 Range of pH of soil is best soil for maximum growth of Plant.

Fig. 2: Morphology Of Mango Ginger.

2.3 Ethnobotanical & Medicinal Importance

Like other species in the genus Curcuma, C. amada has a long history of traditional use in folk medicine in diverse ethnic groups and as an ingredient in culinary preparations in the Indian subcontinent. Ethnobotanical studies have been conducted mainly in India. however, local language documentation and scientific reports are available with very limited access in many Asian countries such as Myanmar and Thailand. Curcuma is used medicinally as a coolant, aromatic and astringent, and is used to promote digestion. A rhizome paste has traditionally been used for healing of wounds, cuts and itching.

The external use of the rhizome paste for sprains and skin diseases is also an old practice. The rhizome has carminative properties, as well as being useful as a stomachic. Due to its raw mango-like aroma, it is also used in salad, other culinary preparations, and for making pickles in different parts of India. A whole plant paste with crushed long peppers (Piper longum) is reported to be effective for the treatment of piles, and a decoction of rhizome (3 mL) with common salt (2 g) is an effective treatment for colds and coughs. The C. amada rhizome is considered good as a stomachic because it has bitter, aromatic, cooling, astringent and carminative qualities Combined with other medicines, rhizomes are also used to improve blood quality. Mango ginger is used therapeutically as a carminative and stomachic, and topically for contusions and sprains.

Fig. 3: Benefits Of Mango Ginger.

2.4 Volatile Constituents

There are many reports on the composition of mango ginger volatile oil. The mango flavour is mainly attributed to presence of car-3-ene and cis-ocimene among the 68 volatile aroma components present in the essential oil of mango ginger rhizomes. The cis- and transhydroocimene, ocimene and myrcene were found to be the major compounds present in the volatile oils of C. amada, which indicates that the aroma of mango ginger is amixture of characteristic compounds found in both raw mango and turmeric (Rao et al. 1989). The acetone extract of mango ginger is composed of colourless oil,

curcumin, phytosterol and azulenogenic oil containing pinene, camphor, curcumene and ar-turmerone (Jain and Mishra 1964). There are more than 100 phytochemicalsreported from fresh and dried extracts of C. amada.

2.5 Chemical Constituents

Proximate and nutrient analysis of edible rhizome plays a crucial role in assessing their nutritional significance and nutraceutical quality. The mango ginger rhizome was found to be a rich source of fibres and starch. It has been widely recognized that bioactive chemicals play a variety of roles in fruits, vegetables, tubers and rhizomes, serving as precursors to give distinctive flavour, colour, defence intermediates and health-promoting elements. The literature lacks any publications on the purification and characterization of bioactive compounds from mango ginger, despite the rhizome's numerous therapeutic benefits and great food value due to its unique flavour .Plants and herbs have medicinal qualities because of the existence of bioactive elements such flavonoids, alkaloids, saponins, glycosides, tannins, steroids and phenolic compounds, among others 38. The Plant extracts serve as a rich source of bioactive compounds, showcasing a diverse array of structures that contribute to their therapeutic potential.

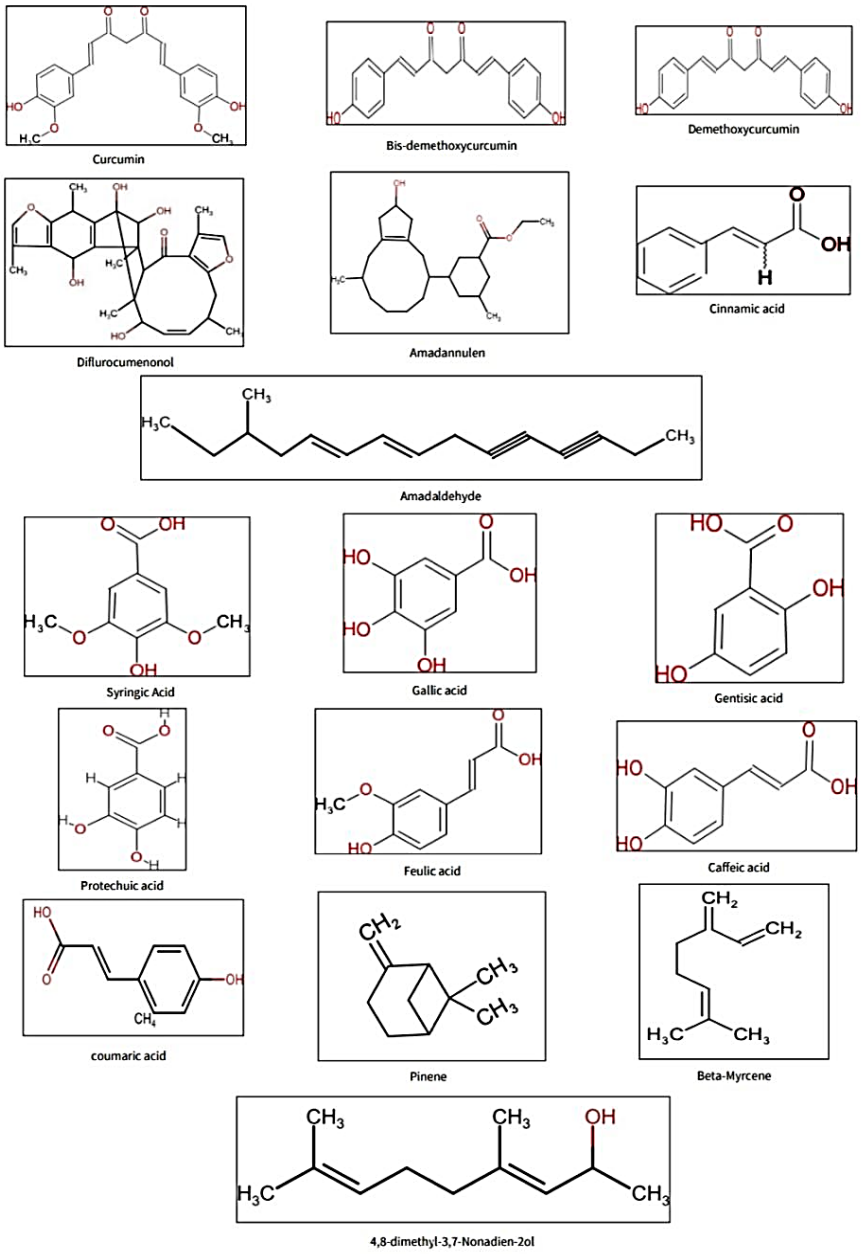

Fig. 4: Chemical Constituents.

2.6 Pharmacological Uses

1. Anti-bacterial activity: The rhizomes essential oil exhibits significant Antibacterial activity. Difurocumenonol, amadannulen and Flavonoids are responsible for the antibacterial activity of Mango ginger. The chloroform rhizomes extract of mango Ginger was used for determination of antibacterial activity Against P.aeruginosa M. luteus, S.aureus,, E. coli, S. typhi, E. fecalis, B. subtilis, B. cereus K. pneumoniae, Y. Enterocolitica, E. aerogenes, P. mirabilis, and L. Monocytogenes. Moreover, they reported that Difurocumenonol and amadannulen compounds responsible For their antibacterial activity. Another study reveal that Rhizome of mango ginger exhibited significant antibacterial activityagainst various bacterial strains S. aureus, S. typhi, S. dysenteriae, P. aeruginosa, P. mirabilis, C. albicans and C. trophicali. There results showed that antibacterial Activity of plant was affected with changing of rhizomes Extract concentrations. Flavonoids a major group of Phenolic compounds were reported for their antibacterial Activity.

2. Cholesterol lowering activity: Rhizomes powder was used to evaluate the Cholesterol lowering activity of mango ginger against female Wistar rats. 100-200 g/mg dose of mango ginger was Significantly reduced the blood cholesterol level. The results Showed that curcumin compound might be responsible for Reduction of liver cholesterol in animals.

3. Antifungal activity: Antifungal activity of mango ginger rhizomes Extract was determined against F. moniliforme, Curvularia Palliscens, A. terreus, Aspergillus niger, and F. falcatum Fungal strains. There results showed that mango ginger Exhibited strong antifungal activity. The myrcene and Pinene volatile compounds of mango ginger essential oil Were might be responsible for antifungal activity.

4. Anti-hyperglycemic activity: The rhizomes aqueous methanolic (1:4) extract was Tested in alloxan-induced diabetic and normal mice. This Extract showed time and concentration dependent anti-Hyperglycemic activity. Various doses 150, 250, 350, 450, 550 and 650 mg/kg showed different reduction in blood Glucose level of 25%, 48%, 63%, 67%, 68% and 68 Respectively in mice. Moreover, it was reported that extract Dose of 650 mg/kg showed highest anti hyperglycemic Activity.

5. Anthelmintic Activity: Rhizomes extract of different solvents (petroleum Ether, ethanol and water) were used to determine the antihelmintic activity. Three different concentrations (50mg/ml, 100mg/ml and 150mg/ml) of each solvent were tested on Earthworms. The results showed that all the extracts of plant Exhibited dose dependent activity and 150 mg/ml extract of Mango ginger was more effective in causing death of earth Worms than 50mg/ml and 100mg/ml. The carbohydrates, glycosides, phytosterols, resins and flavonoids Compounds of mango ginger extract was might be Responsible for antihelmintic activity.

6. Anti-tubercular activity: The chloroform extract of mango ginger rhizomes Was used for the determination of anti-tubercular activity. Labdane diterpene dialdehyde was exhibited strong antitubercular activity at 500 mg/mL concentration against Mycobacterium tuberculosis.

7. Anti-spermatogenic activity: The continuous falling of electromagnetic radiation On human as well on animals gives much dangerous effect, Especially reduce sperm counts and increase infertility. The Extract of mango ginger was tested to determine sperm Counts in male mice and man and also checked motility and Level of testosterone hormone in both. Optimum Concentration of extract exhibited efficient results. These Results showed that extract of mango ginger significantly Improved sperm count, level of testosterone hormone and Motility.

8. Anticancer activity: Methanol extract of leaves and rhizomes of mango Ginger were tested for describing of anti- cancer activity Against breast cancer. The anti-cancer activity was checked By diphenylamine method that showed methanol extract of Rhizomes and leaves of mango ginger induce cell death in Breast cancer lines MDA MB 231 and MCF-7. Terperniods And steroids compounds might be responsible for anticancer Activity. In another study, mango ginger showed strong Anticancer activity.

9. Anti-Pyretic Activity: The aqueous rhizomes extract of mango ginger was Applied in the rabbits for determination of anti-pyretic Activity. Different dose of extract were used, 200 mg/kg Dose of rhizomes of mango ginger showed efficient Reduction of prostaglandin synthesis in hypoalamus. The Tannins, alkaloids, steroids and glycosides compounds of Mango ginger might be responsible for their antipyretic Activity.

10. Antioxidant activity: Antioxidant properties of plant are due to the Presence of phenolic or flavonoid components [6-21-24]. The rhizomes hydro-distilled essential oil and extracts of Mango ginger was used to determine the antioxidant Activity. The antioxidant activity of different solvent extracts and rhizomes essential oil was tested by DPPH radical assay. The rhizomes essential oil and different solvent extract Of mango ginger showed strong antioxidant property. The presence of curcumis and curcuminoide might be Responsible for antioxidant activity.

2.7 Uses

- 2-3 g of the powder of the rhizome of mango ginger is added with a glass of buttermilk and given to treat conditions of indigestion and improve taste and appetite.

- The paste of the rhizome of Curcuma amada is applied over the joint affected with localized pain and swelling.
- The juice of the rhizome of amragandha haridra is given in a dose of 10 ml to treat intestinal worms.
- 5-10 ml of the fresh juice of Mango ginger is mixed with a few drops of honey and consumed to treat cough and asthma.

3. MATERIAL AND METHODS

3.1 Extraction Methods

3.1.1 Plant Materials Collection And Essential Oil Extraction: The rhizomes of Curcuma amada weighing 17–25 g were collected and planted in individual grow bags at a depth of 4–6 cm. The rhizomes were watered every day and nutrients were provided after germination in terms of Nitrogen: Phosphorus: Potassium at a ratio of 3:3:6. The plants were kept in a semishaded area with a temperature of 28 ± 2.5◦C and humidity of 92%. The plants were allowed to grow for six months and harvested after that. The rhizomes of the C. amada were collected, washed to remove soil, and dried. The extraction of essential oil was done by different methods including hydrodistillation, steam distillation, microwave or ultrasound-assisted distillation, as follows. Each extraction was carried out in triplicate and compared the yield and composition for uniqueness.

3.1.2 Hydro-Distillation: The powdered rhizome of C. amada (200 g) was added to a Clevenger type apparatus (Borosil, India) for hydrodistillation for 4 h. Then added sodium chloride (1 g) and dichloromethane (20 mL) to the aqueous distillate in a separating funnel. Further, continual shaking was performed for 40 min and allowed to stand for 20 min. After settling, the organic layer was extracted and concentrated. The oils existed in the organic layer were further dried over anhydrous sodium sulfate and collected in a vial then sealed and preserved at 4 ◦C until further analysis.

3.1.3 Steam Distillation: Steam distillation is one among the commonly used method for essential oil extraction; the present study adopted the instructions provided by reports of Manzan et al. (2003). The C. amada powdered fresh rhizome was (200 g) was subjected to Steam distillation for 5 h in a steam distillation apparatus. About 2 g of NaCl and dichloromethane (50 mL) was mixed with the distillate. The organic layer was separated and concentrated to 5 mL and oil was stored in glass tubes at 4 ◦C.

3.1.4 Microwave-Assisted Extraction (Hydro-Distillation): The extraction was set up in line with the previous descriptions of Moradi et al. (2018). The fresh and powdered rhizomes of C. amada were rehydrated in water and exposed to the irradiation frequency of 2450 MHz and then subjected to hydrodistillation. The finally extracted essential oil was stored under refrigeration.

3.1.5 Ultrasound-Assisted Extraction: The extraction was carried out according to the techniques and tools described in the studies of da Silva Moura et al. (2020) with certain amendments. The fresh powdered Phoenix Ultrasonic Cleaner (SGM Lab solutions, Bengaluru, India) at a frequency of 40 kHz for approximately 30 min (input power 50 W). In the end, the extract was collected and further subjected to hydrodistillation using Clevenger-type apparatus (Borosil, India) for another 5 h. The collected essential oil was then dried using sodium sulfate and preserved at 4 ◦C for usage.

3.2 Methods & Analysis

3.2.1 Gas Chromatography/Mass Spectrometry (GC/MS) Analysis: The composition of C. amada rhizome essential oils was analyzed using Varian CP 3800 GC/MS. The GCMS analysis conditions were as described in the previously published works of Padalia et al. (2013). The column used was 30 m × 0.25 mm inner diameter with a thickness of 0.25 µm. The carrier gas used was Helium gas (flow rate of 1 mL/min). The injector temperature was set at 250◦C and the oven temperature was raised from 50◦C to 200◦C at a rate of 8◦C per minute. The identification was carried out using the NIST library according to the standard methods described in the previous reports of Padalia et al. (2013).

3.2.2 Determination Of Minimum Inhibitory Concentration (MIC): The determination of MIC was according to the standard protocols described by Standard methods (ESCMID, 2000). The bacterial cultures were maintained in the log phase of growth, and a loop of cells was transferred to lactose bile broth and incubated at 37◦C for 24 h in a bacteriological incubator. The bacterial density was set to 107 CFU/mL by spectrophotometric determination at 600 nm using appropriate dilution using fresh LB broth. Further, 25 µL of the inoculum was then added to microplates containing different concentrations of C. amada essential oils (0–10 mg/mL) and incubated for 24 h. The MIC was estimated as the lowest concentration of essential oil which had no visible growth after 24 h.

3.2.3 Larvicidal Activity Of C. Amada Essential Oils Prepared By Different: The cultures of Armigeres subalbatus, Aedes aegypti, and Culex tritaeniorhynchus were maintained for 10 generations. The third instar larvae (50 Nos) was collected from the colony and placed in a 50 mL beaker and different concentrations of essential oils were added by dissolving in DMSO (0.5 mL) and made up to 50 mL with double distilled water. The mortality at the end of 24 and hours in each concentration of essential oil was determined by counting the dead larvae and the percentage of death and LC50 was estimated.

3.2.4 Non-Targeted Species Toxicity In Guppy Fish (Poecilia Reticulata) The model organism for non-targeted toxicity was chosen as Guppy Fish (Poecilia reticulata) (P Ferreira et al., 2019); approximately guppy

Fishes of average body length of 3.2 ± 0.2 cm and weight of 1.24 ± 0.12 G were chosen for the study. The concentration of essential oil tested was The same as that of those used for larvicidal studies; in each concentration six guppy fishes were placed and exposed for the respective concentrations over 48 h. The guppies were observed for any sign of toxicity Or behavioral changes which were recorded immediately and also during 1, 6, 12, 24, and 48.

3.2.5 Phenolic Content In Mango Ginger Extracts: The free phenolic acids (figure 4) present in mango ginger are caffeic (26%, 195 mg/g), gentisic (24%, 180 mg/g) and ferulic (20%, 150 mg/g) followed by gallic (10%, 75 mg/g), cinnamic (7%, 52.5 mg/g), protocatechuic (7%, 52.5 mg/g) and small amounts of syringic (4%, 30 mg/g) and p-coumaric acids (2%, 15 mg/g). It also contains bound phenolic compounds like ferulic acid (47%, 391.5 mg/g) and cinnamic acid (29%, 237 mg/g), p-coumaric acid (11%, 95 mg/g), syringic acid (5%, 38.8 mg/g), gallic acid (1%, 11.5 mg/g) and gentisic acid (1%, 4.9 mg/g).

4. CONCLUSION

This study demonstrates the successful extraction of *Curcuma amada* essential oils using four different methods: hydro-distillation, steam distillation, microwave-assisted extraction, and ultrasound-assisted extraction. Among these, variations in yield and composition were observed, indicating that the extraction technique significantly influences the chemical profile of the oil. GC/MS analysis revealed the presence of diverse bioactive compounds, particularly phenolic acids such as caffeic, ferulic, and gentisic acids, which contribute to the plant's therapeutic properties.

The essential oils exhibited notable antibacterial and larvicidal activities, with minimum inhibitory concentrations (MICs) determined against selected bacterial strains and effective larvicidal action observed against mosquito species such as *Aedes aegypti*, *Culex tritaeniorhynchus*, and *Armigeres subalbatus*. Importantly, non-target toxicity testing in guppy fish (*Poecilia reticulata*) showed minimal adverse effects, indicating the ecological safety of the oils at tested concentrations.

Overall, *C. amada* essential oils, particularly those extracted using advanced techniques like microwave- and ultrasound-assisted methods, hold promise as natural antimicrobial and insecticidal agents, with low toxicity to non-target organisms. These findings support further exploration into their application in pharmaceuticals, pest control, and other biotechnological fields.

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