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A Review on Phythochemical and Pharmacological Aspects of Mango Ginger (Kurkuma Amada)

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Abstract: *Mango ginger (Curcuma Amada Roxb.) is a unique spice having morphological resemblance with ginger but imparts a raw mango flavour. The main use of mango ginger rhizome is in the manufacture of pickles and culinary preparations. Ayurveda and Unani medicinal systems have given much importance to mango ginger as an appetizer, alexiteric, antipyretic, aphrodisiac, diuretic, emollient, expectorant and laxative and to cure biliousness, itching, skin diseases, bronchitis, asthma, hiccough and inflammation due to injuries. The biological activities of mango ginger include antioxidant activity, antibacterial activity, antifungal activity, anti-inflammatory activity, platelet aggregation inhibitory activity, cytotoxicity, antiallergic activity, hypotriglyceridaemic activity, brine-shrimp lethal activity, enterokinase inhibitory activity, CNS depressant and analgesic activity. The major chemical components include starch, phenolic acids, volatile oils, curcuminoids and terpenoids like difurocumenonol , amadinone and Amad aldehyde. This article brings to light the major active components present in C. Amada along with their biological activities that may be important from the pharmacological point of view*

Keywords: Antimicrobials; antioxidants; biological activities; biochemical constituents; Curcuma amada; Mango ginger

I. INTRODUCTION

Several epidemiological studies established a link between phytochemicals and the range of biological activities that impart health benefits in human beings. Scientific research supports the biological activity of many of the phytochemicals more in their native forms. They were copiously used in Ayurveda and other traditional medicine (Moon et al. 2010), which dates back to Charaka Samhita (Gupta et al. 2010). Amongst the Phytochemicals, several groups of polyphenols (anthocyanins, proanthocyanidins, flavanones, isoflavones, resveratrol and ellagic acid), non-nutrient chemical and dietary constituents are currently used in the pharmaceutical industry. The spices are considered to be the storehouse of active phytochemicals. The various spices belonging to the genus Curcuma are well known for their multiple uses as medicines, cosmetics, dyes, flavourings and nutraceuticals. Extensive work has been carried out on Curcuma longa (turmeric) and Zinger officinal (ginger), but Curcuma Amada (mango ginger) is an untapped medicinal plant of the ginger family. This review explores the phytochemicals and their biological activities of C. Amada.

BOTANY AND TAXONOMY OF CURCUMA AMADA:

Curcuma Amada is a unique spice having morphological resemblance with ginger (Zingiber officinale) but imparts a raw mango (Mangifera indica) flavour. The genus name Curcuma was coined by Linnaeus in 1753 in his Species Plantarum. The word probably derives from the Arabic word ‘kurkum’, which means yellow colour (Salvi et al. 2000; Shirgurkar et al. 2001). Curcuma Amada Roxb. is commonly known as mango ginger. It is a perennial, rhizomatous, aromatic herb belonging to the family Zingiberoside. This family is composed of 70–80 species of rhizomatous annual or perennial herbs (Purseglove 1974; Aminul 2004). The genus originated in the Indo-Malayan region, and is widely distributed in the tropics of Asia to Africa and Australia (Sasikumar 2005). The plant grows to a height of 1 m (figure 1A). The leaves are long, oblong, lanceolate, radical, sheathed, petiolate and in tufts. Each plant bears 5 to 6 pairs of

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leaves. Mango ginger rhizomes (figure 1B and C) are fleshy, buff coloured, 5–10 cm long, 2–5 cm in diameter and demarcated into nodes and internodes. At the rhizome nodes scaly leaves are arranged circularly giving the appearance of growth rings with scars on the surface. The rhizomes are branched, and the branching is sympodial. The rhizomes emulate a raw mango flavour and taste pungent.

The taxonomical hierarchy of mango ginger is as follows:

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

OCCURRENCE AND DISTRIBUTION:

The geographical distribution of this genus ranges from India to Thailand, Indo-China, Malaysia, Indonesia and northern Australia. C. Amada is found the wild in parts of West Bengal, and is cultivated in Gujarat, Uttar Pradesh, Kerala, Karnataka, Tamil Nadu and the north-eastern states. They originated in the Indo-Malayan region and distributed widely in the tropics from Asia to Africa and Australia (Sasikumar 2005). Out of 10 Curcuma species, 2 species, C. Amada and C. zedoaria, are distributed throughout India in the wild and cultivated forms; 4 species, C. aeruginosa, C. brog, C. cassia and C. sylvatica, occur in wild conditions and distributed throughout north-eastern part of India. C. malabaricane and C. aromatic occur in south India, while C. raktakanta and C. harita are distributed throughout Kerala (Velayudhan et al. 1999).

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 (Lakshminarayana et al. 1963).

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 (figure 2) among the 68 volatile aroma components present in the essential oil of mango ginger rhizome (Dutt and Tayal 1941; Golap and Bandyopadhyay 1984; Rao et al.

Figure 1: Mango ginger plant (A), rhizomes (B) and TS of rhizome (C).

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Mango ginger for phytochemicals and biological activities.

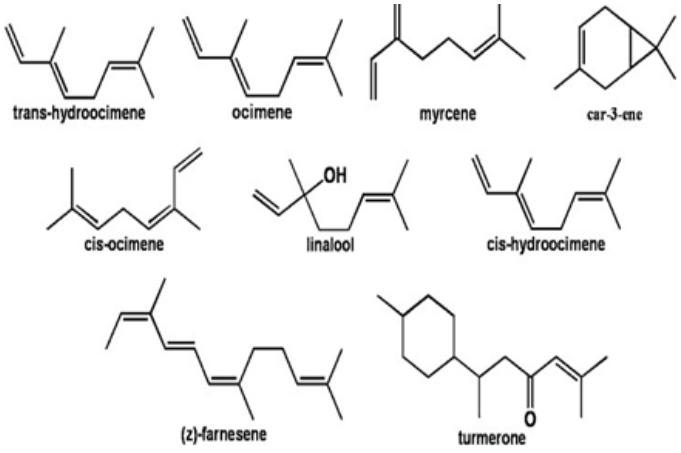

Figure 2: Volatile constituents of mango ginger

1989; Choudhury et al. 1996; Srivastava et al. 2001; Singh et al. 2003a, b; Mustafa et al. 2005). The cis- and transhydro ocimene, 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 a mixture 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, curcumins and ar-turmerone (Jain and Mishra 1964). There are more than 100 phytochemicals reported from fresh and dried extracts of C. Amada as compiled by Jatoi et al. (2007).

CURCUMINOIDS IN MANGO GINGER

The well-known curcumin, dimethoxy curcumin and bis-dimethoxy curcumin (figure 3) are the major constituents from acetone extract of C. Amada (Gupta et al. 1999).

PHENOLIC CONTENT IN MANGO GINGER EXTRACTS

The free phenolic acids (figure 4) present in mango ginger are caffeic (26%, 195 mg/g), gentilic (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) (Sundaraja and Dharmesh 2007). 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), caffeic acid (4%, 30.7 mg/g), gallic acid (1%, 11.5 mg/g) and gentilic acid (1%, 4.9 mg/g).

TERPENOID BIOACTIVE MOLECULES

Three terpenoid bioactive compounds, viz. difurocumenonol, amadannulen and Amad aldehyde (figure 5), were successfully isolated and characterized from chloroform extract of C. Amada rhizome (Policegoudra et al. 2007a,b, 2010).

The bioactive compounds are antibacterial as well as antioxidant in nature with DPPH radical scavenging activity, superoxide radical scavenging activity, lipid peroxidation inhibitory activity, metal chelating activity and total reducing power. The above bioactive compounds were also potential platelet aggregation inhibitors and toxic for cancer cell lines (Policegoudra 2008; Policegoudra et al. 2010).

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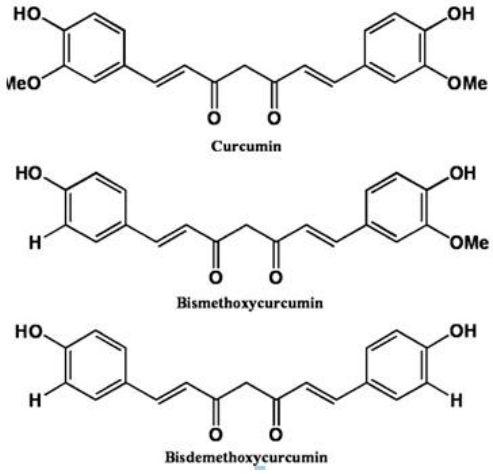

Figure 3: Curcuminoids from mango ginger

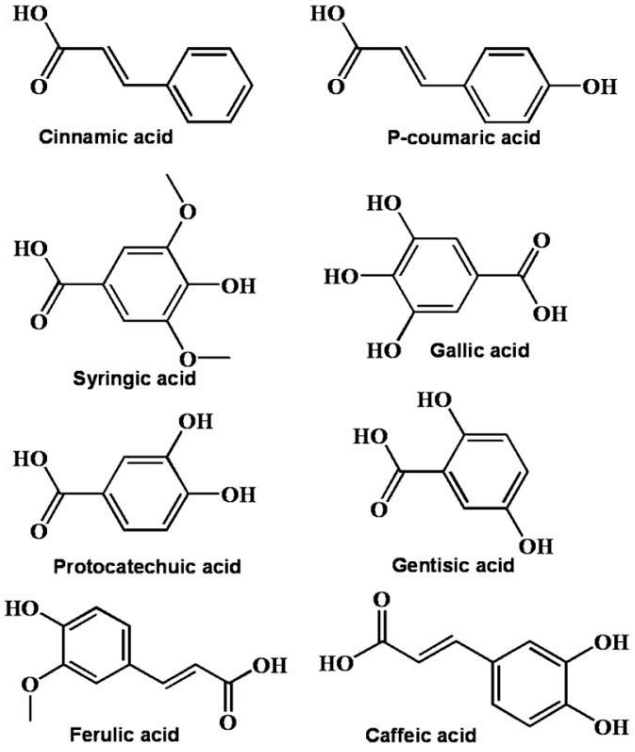

Figure 4: Phenolic acids from mango ginger

FUNCTIONAL ATTRIBUTES OF CURCUMA AMADA STARCH

It appears that starch from mango ginger has potential functional properties. The starch from an unconventional source like mango ginger was isolated and characterized by Policegoudra and Aradhya (2008). It has a distinct structural and biochemical features of its own. Mango ginger contains 1.3% ash, 9.8% moisture and 45% starch with 43% amylose. Morphologically, mango ginger starch resembles ginger starch granules, but it differs by the absence of fissures on the surface and its X-ray diffractogram pattern. Scanning electron micrograph (SEM) revealed the variations in shape of granules that appeared as round, elliptic, irregular and polygonal (figure 6). The granule size was between 3 and 20 µm

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for small granules and 20 and 48 µm for large granules and belongs to 'B' type of starch, a characteristic feature of Curcuma species. Thus, it occupies a unique position between turmeric and ginger starch. The solubility and water holding capacity of mango ginger starch was linear with increase in temperature. High amylose content and low solubility are interesting attributes of mango ginger starch that need to be explored for preparation of nutraceutical products of metabolic advantages.

ACCUMULATION PATTERN OF BIOACTIVE COMPOUNDS DURING DEVELOPMENT

It may have been a biological inevitability for mango ginger rhizome to develop compounds of multifunctional activity to counteract the diversified underground abiotic and biotic.

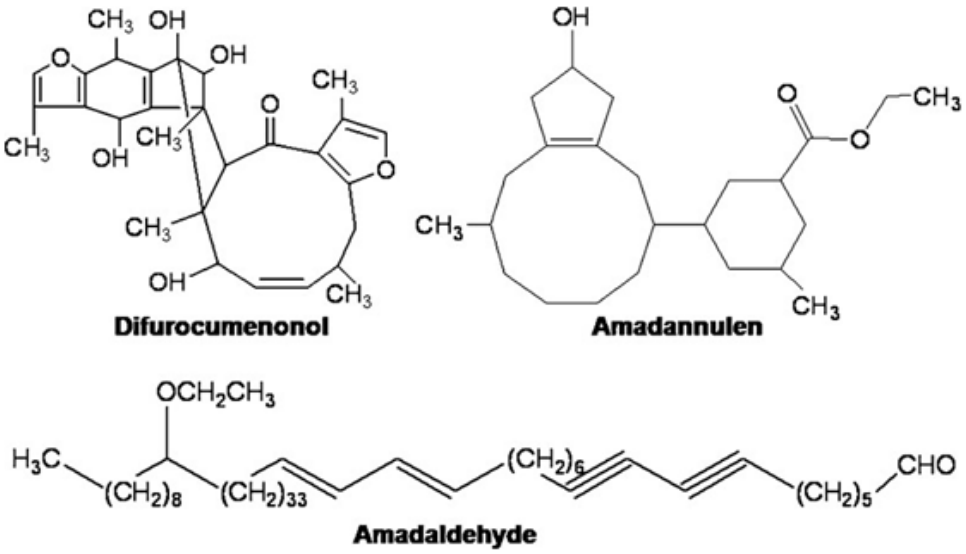

Figure 5: Terpenoids from mango ginger.

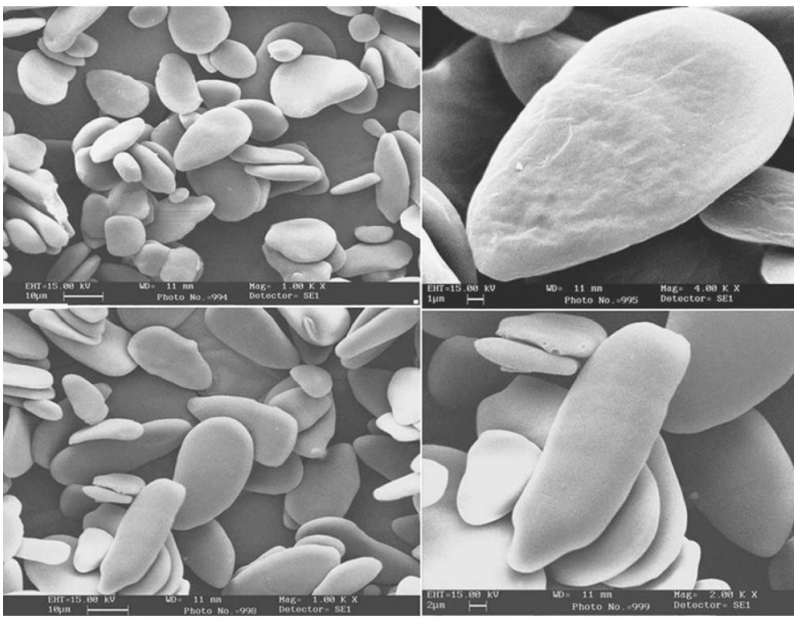

Figure 6: Starch granules of mango ginger rhizomes.

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other visual parameters in mango ginger, which provided optimum period for harvesting of mango ginger rhizomes, endowed with phytochemicals for various medicinal properties mentioned earlier (Policegoudra et al. 2007c). Biosynthesis and accumulation pattern of difurocumenonol, phenolics and protein concentrations are maximum in 150- to 180-day-old rhizomes. High concentration of bioactive compounds and other storage components are critical and a play important role as a biomarker to determine the quality index of C. Amada rhizomes for its utility in food and pharmaceutical industry (Policegoudra et al. 2007c).

FATE OF BIOACTIVE COMPOUNDS AT DIFFERENT TEMPERATURES.

Stability of the phytochemical compounds and their unaltered biological activities in prolonged storage condition are the preferred qualities for production of nutraceutical and pharmaceutical products. Selection of plant material plays a crucial role in deciding the product quality. Less information is available in this regard especially with regard to bioactive phytochemicals. For the first time, difurocumenonol, a multi-functional bioactive terpenoid compound, has been successfully shown as biomarker to assess the bioactive quality changes in mango ginger rhizome during storage at different temperatures (Policegoudra 2008) (figure 7). The highest concentration of difurocumenonol in 70 days stored rhizomes at ambient conditions becomes useless for product preparation due to decrease in its concentration of major phytochemicals. Retention of major phytochemicals and difurocumenonol for longer period (120 days) can be achieved by storing mango ginger in low temperature (14±1°C). It also retained the mango flavour and minimized the changes in phytochemical composition and antioxidant properties. Thus, phytochemical and biological activity mango ginger was observed to be directly governed by temperature and time of storage (Policegoudra et al. 2007c).

MANGO GINGER AND ITS USE IN TRADITIONAL MEDICINES (AYURVEDA AND UNANI)

The ancient testimony for the use of plants as medicine was well documented in the treatise of Ayurveda and dates back to the pre-historic Vedic era. Accordingly, the medicinal

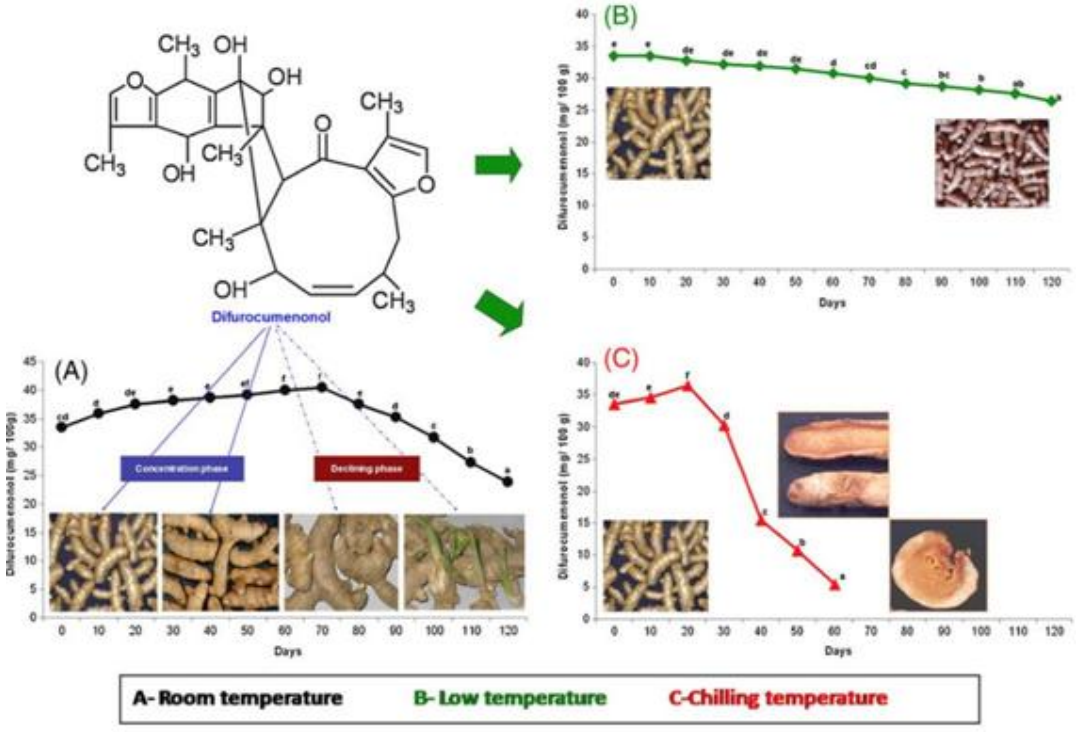

Figure 7:Changes in bioactive principles of mango ginger at different temperature.

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USE OF MANGO GINGER IN FOOD INDUSTRY

Mango ginger has a typical exotic flavour of raw unripe mango. Therefore, it is used as a basic ingredient in pickles, preserves, candies, sauces, curries, salads and so on (Verghese 1990; Shankaracharya 1982).

BIOLOGICAL ACTIVITIES OF CURCUMA AMADA

Rhizome, being a storehouse of bioactive compounds, has extensive use. Mango ginger is used medicinally as a coolant, aromatic and astringent and to promote digestion. A rhizome paste has traditionally been used for healing of wounds, cuts and itching (Srivastava et al. 2006). The external use of the rhizome paste for sprains and skin diseases is also an old practice (Gupta et al. 1999a,b). The rhizome has carminative properties, as well as being useful as a stomachic (Hussain et al. 1992).

Very few reports are available on the aerial parts of the plant. However, a whole-plant paste with crushed long peppers (Piper longum) is reported to be effective for the treatment of piles, and a decoction of the rhizome with common salt is an effective treatment for colds and coughs and is used to improve blood quality (Kapoor 1990). Topical use of native extract of leaves for contusions and sprains are also reported by several authors (Kirtikar and Basu 1984; Nadkarni 1954; Rao et al. 1989).

ANTIOXIDANT ACTIVITY

The antioxidant activity of aqueous methanol extract of mango ginger leaves and rhizomes by β-carotene bleaching method are reported (Prakash et al. 2007). Leaf extract was more active than rhizomes extract. The antioxidant activity of sequential extracts of mango ginger with increasing polarity of solvents was reported by Policegoudra et al. (2007a). They reported different antioxidant activity assays like DPPH radical scavenging activity, superoxide radical scavenging activity, metal chelating activity and lipid peroxidation activity. Among hexane, chloroform, ethyl acetate, acetone and methanol extracts, ethyl acetate and acetone extracts showed good DPPH radical scavenging activity. The non-polar extracts showed good lipid peroxidation inhibitory activity. The antioxidant activity of mango ginger rhizomes in fresh and cooked form has demonstrated that there are no significant differences in the utilization of mango ginger for preparation of culinary preparations (Tar wadi and Agta 2005).

ANTIBACTERIAL ACTIVITY

The aqueous and organic solvent extracts of mango ginger are antibacterial against Escherichia coli, Bacillus subtilis and Staphylococcus aureus (Chandarana et al. 2005). The heated aqueous extract exhibited high antibacterial activity compared to the unheated aqueous extract. Chandarana et al. also reported that the solvent extracts (1,4-dioxan and DMF) were less effective against bacteria. Antibacterial activity of free and bound phenolics from mango ginger rhizomes has been reported by Siddaraju and Dharmesh (2007). Both free and bound phenolic fractions of mango ginger are effective in inhibiting H+, K+-ATPase activity and Helicobacter pylori growth. Cinnamic and ferulic acids present in phenolic fractions of mango ginger contribute significantly to H+, K+-ATPase as well as H. pylori growth inhibition. The different extracts like hexane, chloroform, ethyacetate, acetone and methanol extracts are highly antibacterial against Bacillus cereus, B. subtilis, Micrococcus luteus, Staphylococcus aureus, Listeria monocytogenes, Enterococcus fecalis and Salmonella typhi (Policegoudra et al. 2007a, b). These extracts showed antibacterial activity against wide range of bacteria. The chloroform extract was more effective when compared to other extracts. However, E. coli, Enterobacter aerogenes, Klebsiella pneumoniae, Pseudomonas aeruginosa, Proteus mirabilis and Yersinia enterocolitica were not inhibited by any of the extracts of mango ginger.

ANTIFUNGAL ACTIVITY

The volatile oil from mango ginger rhizomes has antifungal in nature (Singh et al. 2002). Myrcene (4.6%) and pinene (80.5%) are the major components of volatile oils responsible for antifungal activity against the wide range of fungi, viz. Curvularia palliscens, Aspergillus niger, A. terreus, Fusarium moniliforme and F. falcatum.

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ANTI-INFLAMMATORY ACTIVITY

The ethyl alcohol extract of mango ginger rhizome has anti-inflammatory activity in acute and chronic administration in albino rats (Mujumdar et al. 2000). Mujumdar et al. also reported the presence of chemical compounds with hydroxyl, ester, carbonyl and olefin functional groups in ethyl alcohol extract. It was found to be significant at higher concentrations in acute carrageenan-induced rat paw oedema model.

PLATELET AGGREGATION INHIBITORY ACTIVITY

Platelet aggregation inhibitory activity of ethyl acetate extract and acetone extract is reported to be very high compared to methanol extract (Policegoudra 2008). The high platelet aggregation inhibitory activity of ethyl acetate, acetone and methanol extracts appears to be correlated with high phenolic content and to be concentration dependent.

CYTOTOXICITY

Cytotoxicity of the hexane, chloroform, ethyl acetate, acetone and methanol extracts of mango ginger towards both normal and cancer cell cultures were reported (Policegoudra 2008). All the extracts showed comparatively higher toxicity towards cancer cells when compared with normal cells, which is a good indicator of the anticancer property of extracts. Among the five extracts tested, the ethyl acetate extract showed greater toxicity, followed by chloroform, hexane, and acetone and methanol extract. The cytotoxicity results of different extracts of mango ginger indicate that the extracts are less toxic towards the normal cell lines.

ANTIALLERGIC ACTIVITY

C. Amada is reportedly used in various herbal preparations, including antiallergy formulations (Pushpangadan et al. 2006).

BIOPESTICIDE ACTIVITY

C. Amada is highly effective insecticide or pesticide as reported by several studies'. Amada was exhibited 100% adult mortality and a reduction in oviposition, even at 0.5% concentration. Essential oils from C. Amada showed 100% repellent activity (Singh and Singh 1991). Biochemical studies of these promising oils may lead to the development of future pesticides. Insect mortality was 100% at 1% levels after 45 days. In addition, C. Amada was highly effective in inhibiting the emergence of the F1 generation of weevils (Ahmad and Ahmad 1991).

HYPOTRIGLYCERIDEMIC ACTIVITY

Mango ginger extract showed hypertriglyceridemia activity and influences on both liver synthesis and blood clearance (Srinivasan and Chandrasekharan 1992, 1993). They reported hypertriglyceridemia activity on Triton-induced hyperlipidaemic rats.

BRINE-SHRIMP LETHAL ACTIVITY

The water extract of mango ginger rhizomes showed brineshrimp (Artemia salina) lethal activity (Krishnaraju et al. 2006). The lethality value (LC50=6,600 µg, 24 h) was determined by a plot of the percentage of the shrimps killed against the concentrations of the extracts.

The degree of lethality was found to be directly proportional to the concentration of the extract.

CNS DEPRESSANT AND ANALGESIC ACTIVITY

A fraction obtained from ethanol extract of mango ginger rhizome exhibited CNS depressant and analgesic activity (Mujumdar et al. 2004). The active fraction showed reduction in exploratory activity of barbiturate sleeping time, indicating CNS depressant activity. Further, it also showed reduction in acetic acid-induced writhing's, tail-flick response, and carrageenan-induced inflammation, indicating potential antinociceptive and antiphlogistic activity.

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ENTEROKINASE INHIBITORY ACTIVITY AND ANTITUBERCULAR ACTIVITY

The mango ginger also has enterokinase inhibitory activity (Bhat et al. 1981) and antitubercular activity. The labdane-type diterpenoid, labda-8 (17),12-diene-15,16-dial and its modified analogues have antitubercular properties (Singh et al. 2010).

II. CONCLUSIONS

The currently available drugs in the allopathic system of medicine are not so effective in combating a wide variety of complications. The remedial measure may lie in the phytochemicals. Mango ginger appears to be highly potential and had remained unexplored for their bioactive phytochemicals. The available literature on phytochemicals and biological and pharmaceutical properties activities is very impressive. Very less information is available on the aerial parts of the plant. An array of phytochemicals like phenolics, terpenoids and other bioactive constituents were reported in mango ginger rhizome. They were recognized for various biological activities such as antimicrobial, antioxidant, anticancer, anti- inflammatory, antidepressant, antitubercular and platelet aggregation inhibitory activities. It may be concluded that C. Amada contains a number of bioactive divergent ingredients in which one ingredient may act to enhance the action of another ingredient. The varied phytochemical and biological activities of C. Amada reported in the present review may confirm the therapeutic value, for its combating abilities and for its use against multiple diseases. Further, it may be scientific validation for bioactive properties of mango ginger rhizome and its usage in Ayurveda and other traditional medicines. However, the structure– activity relationships and pharmacological activity of these constituents is the need of the hour. Further synthesis of active principles can lead to development of pharmacological products for health benefits.

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