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Mango ginger (*Curcuma amada Roxb.*): A phytochemical mini review

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Abstract

Mango ginger (*Curcuma amada*) is an annual plant that belongs to *Zingiberaceae* family. It has been cultivated throughout the world and used for food flavoring, essential oil applications and in traditional uses for thousands years. Mango ginger contains, manly, *cis*- and *trans*-hydroocimene, ocimene and myrcene. The extent of each chemical constituent varies depending on the type of species or cultivars as well as cultivation conditions; such as weather, irrigation, soil type, pruning and other horticultural practices. Mango ginger is an essential component of several industrial applications especially; food; cosmetics and pharmaceutical and by-products. The extraction of essential oil methods and post-harvest process are the most traditional methods for Mango ginger production in developing countries. Further research on oil extraction methods, maximizing yield per hectare and optimum preservation are needed, especially in post-harvest of mango ginger rhizomes, leaves and roots.

Key words: Zingiberaceae, Myrcene, Cosmetics, Essential oil, Anticancer

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1. Introduction

Curcuma amada is well known as mango ginger, it belongs to the genus *Curcuma* and family *Zingiberaceae*. It has been widely used in food industry and alternative medicines. *Curcuma* genus contain 60 to 100 species, found in different countries of the world including northern Australia, Indian subcontinent, America, Southeast Asia, new Guinea, tropical Africa, southern China, the Indian Subcontinent, New Guinea, Florida and northern Australia [1-3]. The uncertainty in the exact species numbers of *curcuma* genus are largely attributed to the great variability. Curcuma *longa* (turmeric), *Curcuma amada* (mango-ginger) *Curcuma aromatica (*kasthuri turmeric) and *Curcuma zedoaria* (yellow zedoary) are famous plants of this genus. It is difficult to improve genetic of mango ginger by conventional breeding due to the lack of sexual reproduction. There is a great variability reported in colors, flowers and rhizomes of mango ginger. These factors cause variation in chemical composition of plant. The mango ginger is known by different names depending on the location of country in the world. In England, it is typically called mango ginger. In India, specifically in Hindi Ama Hald and amahaldi, in Bangladesh it is called amada. Similarly, it is known as temu mangga in France, ama adrak in Pakistan and mangoingwer in Germany. Mango ginger has a wide range of varieties and cultivars. The plant exhibits strong aromatic smell. The mango ginger exhibits size in range of 36-48 inches (90-120 cm) and spacing range 6-9 inches (15-22 cm). The leaves are extensive, petiolate, and tapering at both ends. The lower side of the leaves is querulous whereas the upper side of leaves is glabrous. Mango ginger grows throughout the year. A pale yellow color of mango ginger is noticed during bloom period. The warmth climate is essential for germination of seeds. Seeds germination of mango ginger is simple. Recently, the wide ranges of mango ginger are growing in worldwide. Origins, growing conditions, genetic makeup, nutritional value of soil and chemo-types are the main factors which effect the essential oil yield as well as chemical composition of mango ginger. The majority of essential oil is concentrated in rhizomes and in fresh leaves of mango ginger. While dried leaves, stems and roots of mango are producing very small essential oil. It is clear that mango ginger is chemically and morphologically is variable due to the influence of external environment. This variability is reflected in wide range of uses of mango ginger.

2. History/Origin

The description related to the origin of many *Curcuma* species especially mango ginger is indistinct and imprecise. The word *Curcuma* probably derived from the

Arabic word 'kurkum', which means yellow color. It was reported that mango ginger was originated from India and widely distributed in the tropics regions of Africa, Australia and Asia [4].

3. Demography/ location

Mango ginger is grown in various climatic conditions, but the hot climatic condition is favorable for maximum growth of mango ginger. Indian soil exhibits large diversity of mango ginger due to the various climatic conditions, vegetation, topography etc. resulting in enriched heterogeneity of mango ginger. Few reports are available on its growth and distribution in South Pacific, China, Pakistan, Thailand and Malaysia. In India, mango ginger is cultivated in Gujarat, Uttar Pradesh, West Bengal, Tamil Nadu, Karnataka, Konkan and in the hills of western coast of India [5]. It is naturally spread in South and South East Asia, along a few species distributing in South Pacific, Australia, and China. The economically important species are cultivated elsewhere in the tropics and ornamental species can be found practically worldwide. Due to low essential oil yield and commercial demand, the absolute data on mango ginger essential oil production is not available. Essential oils of plant generally exhibit numbers of activities such as antioxidant [6] and antimicrobial [7] etc. which are responsible to the use of essential oils against various diseases [8-9]. The South and Southeast Asia continent are the largest producer in the world however, the production of mango ginger is varying from country to country. India is largest producer of mango ginger with 57.5 kg/acre yield. India covers more than 50% production of mango ginger essential oil in worldwide. Moreover China, Pakistan and Iran are also produced significant amount of mango ginger. Asian countries are the largest consumers of dried mango ginger as compare to other countries of the world. Recently, it was reported that consumption ratio of mango ginger is also increased in cold climate countries especially in European countries. The global statistics for the production of the dried mango ginger are hard to obtain. However, global reports are showing that South Asia countries especially India, Pakistan, China are the largest countries in world which producing dried mango ginger.

4. Botany, Morphology, Ecology

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 is bulky and pronged, with a buff-colored peripheral surface. 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 straw-colored 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.

5. Chemistry

Mango ginger is a well-known aromatic plant used as mango flavoring as the rhizomes of mango ginger have the smell of raw-mango. Mango flavor is mainly attributed to *ä*-3-carene and *cis*-ocimene. Mango ginger rhizomes contained curcumin, bis-demethoxycurcumin and demethoxycurcumin. The leaves essential oil of mango ginger mostly composed of furanosesquiterpenoids, namely epi-curzerenone, curzerenone, curzerene and furanogermenone. The two compounds isosorbide and n-hexadecanoic acid were reported in root essential oil of mango ginger.

5.1 Chemical composition

Mango ginger contains small amount of fat contents and gives less caloric contents. It exhibits majorly phenolic class of fatty acids (Das *et al*., 1997). It is well known for source starch, carbohydrates and certain mineral contents. The manganese (Mn) and cobalt (Co) were reported in roots of mango ginger. Mango ginger also contains significant amount of starch, ash, fibre, carbohydrates and glycosides. The roots part of mango ginger exhibited Mn and Co contents (Rai *et al*., 2001). Flavanoids, terpinoids, diterpene dialdehyde, difurocumenonol and amadannulen are well known compounds of mango ginger.

5.2. Pytochemistry

Mango ginger has a good aromatic smell due to the presence of essential oil contents. These contents are varied with different season [10] and are analyzed by GC-MS analysis [6-11-12].The alpha pinene compound of essential oil has specially contributed in aroma of plant. The flavanoids, terpinoids, tannins steriodas, alkaloids and glysocides compounds are also including in mango ginger. The nature of solvent had affected phytochemical of mango ginger extracts. Ethanol rhizomes extract of mango ginger showed that glycosides, resins, phytosterols and tannins compounds were present as major compounds whereas rhizomes aqueous extract of mango ginger exhibited only phytosterols and glycosides. More than 130 chemical constituents have been reported in mango ginger rhizomes, but only 121 compounds have been identified. The major chemical constituents of mango ginger essential oil were

myrcene, ocimene, arturmerone, (Z)-β-farnasene, guaia-6,9-diene, *cis*- β-ocimene, *cis*-hydroocimene, *trans*hydroocimene, α-longipinene, α-guaiene, linalool, β-curcumene and turmerone [13]. Mango ginger rhizomes contained curcumin, bis-demethoxycurcumin and demethoxycurcumin. However, in another study, *cis*- and *trans*hydroocimene, ocimene and myrcene were determined to be the major character-affecting compounds of mango ginger essential oils. Mango ginger is composed of 6.39% of starch by fresh weight basis and 45.64% of starch by dry weight basis. Recently, it was reported that rhizomes of mango ginger contained various fatty acids, caffeic, gentisic acid, ferulic acid, gallic acid, cinnamic acid, and protocatechuic acid, p-coumaric acid and syringic acid. Another study, identification of components in dichloromethane extract of mango ginger by GCMS, revealed the presence of various chemical components such as curcumene, α-curcumene, ß-curcumene, camphor, curzerenone, 1, 8-cineole ,Curcumin, demethoxy curcumin, bis-demethoxy curcumin, caffeic acid, ferulic acid, gallic acid ,cinnamic acid , p-coumaric acid and gentisic acid.

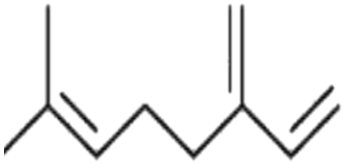

Figure 1. Structure of Myrcene

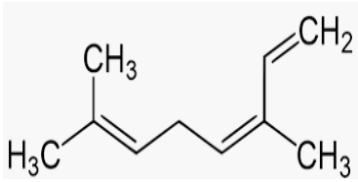

Figure 2. Structure of Ocimene

6. Post harvesting Technology

Review of mango ginger showed that fresh leaves exhibited higher amount of essential oil than dried leaves. The volatile components of essential oil mostly found in fresh leaves of mango ginger. The intense radiations of sun may change some chemical constituents of essential oil and change the post-harvest physiology during storage at ambient temperature, resulting in enhanced or diminished of phenolic compounds. The fresh leaves of mango ginger can be stored under shades for long time preservation. The production of pests in stored leaves destroy the natural flavor of leaves and reduce essential oil yield of mango ginger. Mostly 0.05% of dimethoate or quinalphos compound spray is used to reduce the growth of microbes in storage leaves. However, the higher concentration of these compounds is also affecting yield and change the chemical composition of mango ginger essential oil. The plantation and harvesting of mango ginger are also affecting essential oil yield as well growth of plant. Plantation of mango ginger is mostly done in March to June; due to sunny climate as it increases the growth of mango ginger. The harvesting august to October of mango ginger showed significant essential oil yield. In this period, mango ginger attained its maximum height and rhizomes and leaves are rich in essential oil contents. The fertilizers mostly nitrogen contents based fertilizer also increases growth of mango ginger. The potassium (K) based fertilizer affect and reduces growth of plant. The uses of fertilizer, good time plantation and harvesting, increases the essential oil yield of mango ginger. In freezing method, preservation of leaves of mango ginger is possible for long time storage due to cause of blackening. These characteristics are reduced volatile contents of essential oil of mango ginger. This method is reported as an advanced method that reduced the microorganism growth and increased the yield of essential oil. Furthermore, it is difficult to store leaves of mango ginger for long time due to the oxidative cleavage of fatty acids and various other components of essential oils. The oxidative cleavage of fatty acids, esters and other organic compounds give bad smell and also changes the nature of products.

7. Processing

After harvesting, the rhizomes are washed, sliced and dried in a hot air oven at 50°C for 72 h and powdered to 60 meshes. This powder is used for the preparation of aqueous extract and essential oil extraction. The abstraction of plant extract from mango ginger is mostly done in 25-100°C temperature range by using hydro distillation apparatus. It is simple and easy than steam distillation. Steam hydro distillation is another common method used to extract oil from various parts of mango ginger. It gives good purity of mango ginger essential oil. A modern method based on temperature and velocity is also used for mango ginger essential oil. Ina research, this method was used in 40–70 °C temperature range and 0.84 – 2.25 m/s air velocities range. Then maximum diffusivity was observed in various parts of mango ginger. It gave yield significantly greater than other conventional method. Different parts of mango ginger showed variation in essential oils contents. Rhizomes exhibited higher essential oil yield than other parts (stems, leaves, barks and roots) of mango ginger. That's why stems, barks, roots and leaves known as minor essential oil parts of mango ginger due to low essential oil yield.

8. Value addition

Mango ginger is preferable to be used as a basic ingredient for preparation of many products like pickles, preserves, sauces, curries, candies, salads. But known benefit of mango ginger rhizome is in pickles and culinary manufacturing industries. Ground dried ginger is employed in a wide range of foodstuffs, especially in bakery products and desserts. Mango ginger has significantly unique spice which has similar morphology as ginger but gives a fresh mango flavor. Pummelo fruit juice is blended with mango

ginger and kokum juice. It is diluted into different concentrations, showed fair amount I of ascorbic acid and low total sugar contents. Therefore, pummelo fruit juice can be used by sugar patients. This product can be stored for four months at ambient temperature. This juice can be used as value addition into a refreshing beverage and nectar. It is also reported that mango ginger are using in the preparation of special foods, beverages and pharmaceutical and cosmetic industries.

9. Uses

Mango ginger gives good healthy results in small amount of consumption. It is rich in antioxidant properties and certain mineral compounds. It gives some side effects of large amount consumption of mango ginger. Mango ginger is known as mango ginger due to its particular aroma of raw mango [13]. Therefore, it is widely used in food flavor, teas and in special dishes. It is also using in food dishes as salads. It also has applications in reducing sugar juices, fabric products and starch manufacturing products. In addition, it is also good source of certain mineral and starch. It is well-known for their multiple uses as medicines, cosmetics, dyes, flavorings and neutraceuticals.

9.1. General uses

Natural gums are economic, easily accessible and showed useful applications. The rhizomes of mango ginger exhibited such type of gums and used as tablet binder. Differential scanning colorimetry (DSC) and Fourier transmittance infra-red (FTIR) methods were applied for determination of physicochemical properties of gums. The results of both methods showed that rhizomes of mango ginger had significant gum property. Nanoparticles have wide range of applications in the fields of catalysis, photonics, optoelectronics, biological tagging, pharmaceutical applications, environmental pollution control, drug delivery systems, and material chemistry. The rhizomes extract of mango ginger had been used for synthesis of silver based nanoparticles by some researchers. These synthesized nanoparticles shown numerous applications in various field. Mango ginger is used as spice for pickling. Similar to other members of genus curcuma, it has also many therapeutic properties and is especially useful in digestive disorders. It promotes appetite and improves digestive strength. Similar to ginger it is expectorant and gives relief in cold and cough. It is also recommended in liver inflammation, joint pain, rheumatism and inflammation due to injuries. The rhizomes are made into paste and applied on sprains, bruise, and skin diseases. Decoction of the rhizome is taken to cure dropsy.

9.2. Pharmacological uses

Mango ginger essential oil is known to have strong antioxidant properties. Research has showed that mango ginger essential oil exhibited anti-microbial and anti-cancer properties. Antioxidants are important in maintaining a healthy and balanced lifestyle, mango ginger maybe a very important source of these essential compounds [5]. Furthermore, mango ginger also contains many carcinogenic compounds. The mango ginger extract showed some cytotoxicity with inhibitory concentration, when compared it with other curcuma species. Mango ginger showed higher toxicity than other species of genus *Curcuma*. It showed significant anticancer properties than other related *Curcuma* species. There is extensive diversity in the phytochemical components of mango ginger; these components change drastically with time, cultivation processes and storage. The pharmacological and nutritional properties of the whole plant in nature form, as it has been traditional used due to the presence of various active phytochemical constituents. There is very little data relating to standardized dosage available from traditional practitioners, which is problematic to chemists and pharmacists. There are requiring increasing communication between traditional and orthodox medicines of mango ginger. In this way, our medicines can improve the properties of medicines and concentration of phytochemical. It had reported that rhizomes extract of mango showed highest anti hyperglycemic activity at dose of 650mg/kg [14]. The different solvents extract of mango ginger showed that extracts of mango ginger killed the earthworms at dose 150 mg/ml [15]. The chloroform extract of mango ginger rhizomes was exhibited strong antitubercular activity at 500 mg/mL concentration against *Mycobacterium tuberculosis* [16]. The aqueous rhizomes extract of mango ginger was applied in the rabbits. 200 mg/kg dose of rhizomes of mango ginger showed significantly antipyretic activity [17]. In recent a few decades, an increased methodical interest in plant phytochemical (fruits, dishes and spices) health benefits has been an important subject of plant based nutritional research. Although the study of the plant compounds is not new, scientists are only now started the characterization of bioactive compounds to explore their impact on human health and diseases. In the animal and cell culture studies mango ginger has been found to display antioxidant, anti-inflammatory, antibacterial, antifungal, anti-ulcer, antioxidant, anti-tubercular, anti-hyperglycemic, and CNS depressant activities and analgesic activity.

9.2.1. 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

activity against 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.

9.2.2. 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.

9.2.3. 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.

9.2.4. 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 [14].

9.2.5. Anthelmintic Activity

Rhizomes extract of different solvents (petroleum ether, ethanol and water) were used to determine the anti-helmintic 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, saponins, glycosides, phytosterols, resins and flavonoids compounds of mango ginger extract was might be responsible for antihelmintic activity [15].

9.2.6. Antitubercular activity

The chloroform extract of mango ginger rhizomes was used for the determination of anti-tubercular activity. Labdane diterpene dialdehyde was exhibited strong anti-tubercular activity at 500 mg/mL concentration against *Mycobacterium tuberculosis* [16].

9.2.7. Antispermatogenic 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 [18].

9.2.8. 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 [19]. In another study, mango ginger showed strong anticancer activity [20].

9.2.9. 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 [17].

9.2.10. Antioxidant activity

Antixidant 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 [25].The rhizomes essential oil and different solvent extract of mango ginger showed strong antioxidant property [5]. The presence of curcumis and curcuminoide might be responsible for antioxidant activity [5].

10. Summary and conclusions

Mango ginger (Curcuma *amada Rox*) is an annually growing plant and belongs to family *Zingiberaceae.* It has been cultivated throughout the world and used for thousands of years for food flavoring, essential oil applications and in traditional uses. Mostly mango ginger contains *cis*- and *trans*-hydroocimene, ocimene and myrcene contents. The extent of each of these chemical constituents varies depending on the type of species or cultivars as well cultivation conditions such as weather, irrigation, soil type, pruning and other horticultural practices. Mango ginger is an essential component of several industrial applications that range from food to cosmetics to pharmaceutical products. More uses and applications of mango ginger of mango by-products are continuously added. Post harvesting process, processing and extraction of essential oil methods are most traditional in under developing countries in world. Further

research on oil extraction methods, maximizing yield per hectare and optimum preservation are needed, especially in post harvesting of mango ginger rhizomes, leaves and roots are conventional.

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