Curry plant, *Murraya koenigii* L.: An indigenous spice plant with versatile medicinal property: A minireview

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Abstract

This communication states the biological activities, phytochemical spectrum, medicinal properties, and nutritional potentiality of curry plant, *Murraya koenigii* L. (Family: Rutaceae). The *M. koenigii* is a valued dietary plant used as spice since the ancient times for its characteristic aroma, and in medicine because of its possession of several bioactive compounds with health promoting properties. Curry leaves are rich source of natural antioxidant substances such as tocopherol, β-carotene, lutein, flavonoids, and phenolics. The extracts and essential oil of the plant exhibit antibacterial and antifungal activities. The curry leaves possess potential anticancer activities because of their strong antioxidative properties in various systems. The nutritional potentiality contained in the plant includes minerals, vitamins, carbohydrates, proteins, and fatty acids. Additional information on the bioactive components in *M. koenigii* will help evaluate the health benefits from this functional food plant, and thus, this review updates the facts and phenomena related to the bioactive compounds in curry plant along with their biological activities, due to the web-based search on the topic in SCI and non-SCI journals.

Key words: Antibacterial activity, antioxidant activity, chemistry, curry leaf plant, nutritional potential

INTRODUCTION

India is the enormous reserve for natural resources, and the country holds the wealthy record of conventional medicine system. The indigenous dietary plants (herbs and spices) are fine natural sources of antioxidants, vitamins, minerals, lead molecules of drugs, and flavoring and preservative agents.[1‑4] The curry plant, *Murraya koenigii* L., which is called as “Surabhinimba” in Sanskrit, and “Kaari Pata” in Bengali, belonging to the family Rutaceae, is a spice plant and is one of the most important components in the traditional system of medicine. Curry leaf has a little pungently bitter and softly citrus taste, and is widely used for cooking in India and other Asian countries.

Curry leaves provide a vital ingredient in Indian curries due to its characteristic aroma. The plants are medicinally useful in the treatment as well as prevention of diabetes, cancer, and cardiovascular diseases. The leaves of the plants are full of antioxidants, namely, tocopherol, β-carotene, and lutein, and possess antioxidative and anti-lipid peroxidative activities, providing protection against oxidative stress.[5] Out of a total of 14 global species under the *Murraya* genus, two are found in India: *M. koenigii* (L) Spreng and *Murraya paniculata* (L) Jack, of which the former one has been in access popularly, because of its wide spectrum of medicinal properties, and the use of its leaves since the ancient times as a flavoring agent in different curries and foods.[6] The current review updates the facts and phenomena of *M. koenigii* bioactivity and chemistry due to the scientific data available in web-based SCI and non-SCI journals. Various usage and application of the curry plant are depicted in Figure 1.

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BOTANICALS

The *M. koenigii* L. is a shrub or a small tree [Figure 2], growing up to a height of about 6 m, with dark greenish to brown stem, bipinnately compound leaves, white small flowers (growing apically or in the leaf axils), small ovoid or subglobose fruits, which are fleshy berries with pulp, approximately 1.3 cm long and orange or blackish red, and are seen to occur in close clusters and are glandular with a thin pericarp, seeds having spinach green.[7]

Flowering of the plants starts from the mid-April and ends in the middle of May, however, the peak flowering season has been observed in the last week of April, with the fruiting season in between the middle of July and the end of August.[8] Raina et al. reported four chemotypes of *M. koenigii*, such as β-pinene, α-pinene, β-caryophyllene, and β-phellandrene in India.[9] *M. koenigii* is distributed and cultivated throughout India. Three morphotypes, based on the color and size of leaves and the habitat of the plants, have also been recorded: Brown (most fragrant one with thick smallest dark brown in leaves, slowest growing), regular (fastest growing with dark green leaves available in all parts of India), and Dwarf (bushy with light green leaves), all differing in the intensity of flavor. The plants can be propagated by mounting the small suckers from the bases, by root/shoot cutting, or by seed propagation.[10]

CHEMISTRY

The phytoconstituents present in *M. koenigii* leaves include phenols, steroids, sapogenins, quinones, alkaloids, flavonoids, tannins, carbohydrates, proteins, and volatile oils; the important alkaloids include mahanan, O-methyl murrayamine A, O-methyl mahanane, koene, koenigine, koenidine, girinimbol, bispyrayafoline, girinine, bismahanine.[11] The essential oils [Figure 3] of *M. koenigii* leaves from various locations of Western Ghats, India, as has been reported by Syamasundar et al., were categorized into four chemotypes: β-phellandrene, sabinene, α-pinene, and α-pinene-β-caryophyllene, and the fourth one has been proposed as new chemotype; the contents of chemical groups are represented in Figure 4.[12] The chemical diversity has been evident from the essential oil profiles in respect of monoterpene hydrocarbons: α-pinene (1.93–63.66%), β-phellandrene (1.39–45.89%), sabinene (6.90–40.59%), and sesquiterpene hydrocarbon: β-caryophyllene (6.68–18.46%).[12]

TRADITIONAL USAGE

The plant has been in use since the ancient times in traditional medicine systems in India; the useful parts of the plant included leaves, root, bark, and fruits. Gahlawat et al. documented that the whole plant has been used as antidiarrheal agent, antidepressant, stimulant, and hair tonic, and to cure diabetes, kidney pain, and vomiting while its different parts are useful in various ways: Stem (datan to strengthen gums and teeth), bark (hair tonic, stomachic and carminative), leaves (anti-anemic, analgesic, anti-ulcer and purgative, and for flavoring and seasoning, memory enhancing), fruits (astringent) and roots (cooling agent, reduces inflammation and itching, and curing blood disorders).[13] Kong et al. reported that the roots of *M. koenigii* are used as purgative and...
stimulant as well as in body ache, whereas the bark is used in the treatment of snakebite. The green leaves, dried leaf powder, and essential oil of *M. koenigii* are generally used for flavoring soups, curries, fish, and meat, and also in food preparations, such as dal, sambar, and chutney. Curry leaves are used in dysentery and checking vomiting and applied to bruises and erosion while bark and roots are utilized as stimulants and applied to cure skin eruption and to bite of poisonous animals. It has been recorded that consumption of *M. koenigii* leaves in empty stomach reduces blood sugar of diabetic subjects, taking curry leaves tea with cow milk provides relief from skin infections and rashes while fruit juice cures insect bites and stings of poisonous creatures.

**NUTRITIONAL POTENTIALITY**

The leaves of *M. koenigii* are a good source of minerals (calcium, phosphorus, iron, zinc, magnesium), vitamins (A, E, B, C), and are rich in carbohydrates, proteins, amino acids, and carbazole alkaloids. The dried curry leaf powder has been reported to contain protein (12.5%), fat (5.4%), total ash (9.7%), insoluble fiber (55.6%), soluble fiber (4.4%), iron (12 mg/100 g), phosphorus (373 mg/100 g), and calcium (2.04%). The leaves harvested at three different stages of maturity, such as 10th (early stage), 15th (mid-stage), and 20th (late stage) week of pruning had varied nutritional potential: The early stage showed top carbohydrate content (55.14%), mid-stage recorded top moisture content (6.3%), and late stage possessed top protein (28.08%), crude fiber (10.11%), ash (9.25%), and fat (2.5%) contents. The major nutrient contents of curry leaves, namely, N, P, K, S, and Na were 2.95%, 0.67%, 0.34%, 1.97%, and 0.88%, respectively; the contents of proteins, fats, and carbohydrates were 18.49%, 4.81%, and 68.66%, respectively, and polyunsaturated fatty acid in the form of linoleic acid (14.53 ppm), as reported by Vyas et al. Kale and More reported that curry leaves extract contain considerable amount of carbohydrates and crude fibers, and provide an excellent source of calcium, iron, and phosphorus.

The curry leaves, among the green leafy vegetables, are a rich source of micronutrients, and thus it is essential to encourage people, especially among the population suffering from micronutrient deficiency, for proper utilization of curry leaves nutrition potential in adequate extent incorporated in the diet to mitigate the problems of micronutrient deficiency. Shanthala and Prakash reported that the sensory scores of using dried curry leaf powder were acceptable to the panel members, when incorporated in rice as well as other foods like “chapatti” and seasoned potatoes, for health benefit.

**Antioxidant activity**

Dietary vegetables including curry leaves are rich sources of natural antioxidants. Vyas et al. reported that the curry leaves possess substances such as ascorbic acid (23.41 mg/g), total flavonoid (17.38 mg/g), and total phenol (3.21 mg/g), which are associated with higher antioxidative capacity, thus providing a very good source of dietary antioxidants. The radical scavenging capacity of three varieties of *M. koenigii* methanolic extracts was in the order of Gamthi > Dwarf > Regular, with IC50 values of 171, 365, and 471 μg/ml, respectively, which was corroborated with the phenolic and flavonoid contents of the extracts: Gamthi (532.8 mg/ml) type had the more phenolic content over Dwarf (168.2 mg/ml) and Regular (111.6 mg/ml) types, while the amount of flavonoids were 6.01, 4.82, and 3.58
mg/ml, respectively.[10] Tachibana et al. isolated five carbazole alkaloids from curry leaf extract: Euchestine B, bismurrayafoline E, mahanine, mahanimbicin, and mahanimbine, which in 1,1-Diphenyl-2-picrylhydrazyl (DPPH) system had antioxidative activity in the order of bismurrayafoline E > euchestine B and mahanine > mahanimbicin and mahanimbine while euchestine B and mahanine contributed to high oil stability index value of the M. koenigii leaf extract.[21] The phenolic and flavonoid contents in M. koenigii berry extract (9.5 mg TAE/g and 11.9 mg CE/g of dried powder, respectively) attribute the antioxidative property of the curry leaves.[22] The curry leaf with the highest total flavonoid and total phenolic contents showed the highest antioxidant activity as indicated by the ferric reducing antioxidant potential and DPPH assays.[23]

The DPPH radical scavenging activity with an IC₅₀ values of 4.72, 4.10, and 4.46 μg/ml have been determined, respectively, in acetone, alcohol, and aqueous extracts of curry leaves.[24] Rajnikant et al. showed that the methanolic extract of curry leaves (200 μg/ml) had the highest free radical scavenging potential (65.21%), followed by ethanol extract (59.15%) and the essential oil (10.78%) of M. koenigii.[25]

**Antibacterial activity**

Different scientific studies support the application of M. koenigii as a therapy for a variety of bacterial infections. The most susceptible bacterial strains against leaf extract of M. koenigii were Bacillus subtilis (zone diameter of inhibitions [ZDIs] 11–14 mm; minimum inhibitory concentration [MIC] 0.312 μg/ml) and Staphylococcus aureus (ZDIs 12–16 mm; MIC 0.312 μg/ml), as per the report of Saini and Tyagi.[26] Argal et al. reported that the bacterial strains had moderate effect at low concentration leaf extract of M. koenigii while the efficacy has been increased with the increase of extract concentration.[27] All the extracts of M. koenigii roots have antimicrobial property; the ZDI was directly proportional to the extract concentration used against S. aureus, Micrococcus luteus, B. subtilis, Escherichia coli, Pseudomonas aeruginosa.[28]

Nagappan et al. reported the antibacterial activity, in terms of ZDI, of three major carbazole alkaloids such as mahanine, mahanimbicin, and mahanimbine against Gram-negative and Gram-positive bacteria [Figure 5].[28] and the MICs of these alkaloids ranged 12.5–175 μg/ml, and minimum bactericidal concentration values in between 125 μg/ml and 500 μg/ml; the broad-spectrum antibacterial activity of M. koenigii essential oil is represented in Figure 6.[29] Various extracts of M. koenigii leaves had potent antibacterial activity against both Gram-positive (B. subtilis) and Gram-negative (Salmonella typhi, E. coli, Shigella sonnei) bacteria showing ZDI 8–13 mm and 8–16 mm, respectively, indicating the presence of broad spectrum of antibacterial substances in the plant.[30] As per the report of Vats et al. the MIC of M. koenigii root extracts for B. subtilis (0.625 μg/ml), P. aeruginosa (0.625 μg/ml) and E. coli (0.625–1.25 μg/ml), S. aureus (0.625–1.25 μg/ml) and M. luteus (1.25 μg/ml) indicated the potentiality of the plant in controlling bacterial infection to humans.[28] The antibacterial activity of M. koenigii extracts is depicted in Figure 7.

**Antifungal activity**

The scientific studies also supported the application of M. koenigii as the therapy against the infection of fungal pathogens. The leaf extract of M. koenigii had excellent antifungal activity against Aspergillus brasiliensis, (ZDIs 10–14 mm; MIC 0.312–0.625 mg/ml) and Candida albicans (ZDIs 3–7 mm; MIC 0.625–2.5 mg/ml), as has been reported by Saini and Tyagi.[26] The petroleum ether and chloroform extracts of M. koenigii root exhibited antifungal activity with ZDIs 9–17 and 14–22 mm, respectively, against C. albicans, and ZDIs 9–12 and 9–15 mm, respectively, against Aspergillus niger.[28] The leaf methanolic extract of M. koenigii effectively inhibited the Rhizoctonia solani mycelial growth (70%) and Fusarium oxysporum (58%) while the ethanolic extract was more potent against F. oxysporum (61.07%) compared to R. solani (53.77%), and the essential oil showed moderate activity against both F. oxysporum (55.69%) and R. solani (48.38%).[29] The overall antifungal activity of M. koenigii extracts is depicted in Figure 7.

**FOOD PRESERVATION**

Lipid oxidation in foods causes its quality deterioration (rancidity, off-flavor, degradation of texture, and color...
The SNPs, thus, might be the useful against life-threatening microbial infection caused due to pathogenic fungus and bacteria; such SNPs (size: 10–100 nm) are stronger and promising when compared with the regular metal, and had synergistic activity against potential human pathogenic bacteria including E. coli, S. aureus and P. aeruginosa, as well as fungus including C. albicans. Bonde et al. synthesized SNPs using M. koenigii leaf extract that had bactericidal activity against E. coli, S. aureus and P. aeruginosa alone, and showed synergistic interaction when used in combination with conventional antibiotics. It has been reported that the SNPs synthesized with M. koenigii extract had antimicrobial efficacy against A. niger, A. flavus, Trichoderma, and Rhizopus, and had more efficacy against Rhizopus than the test agents: Amphoterin, and plant extract. The SNPs, thus, might be the antimicrobial agents of newer generation possessing broad antimicrobial spectrum and can potentially be utilized in the preparation of several antimicrobials.

SAFETY AND TOXICITY

The M. koenigii is an important dietary plant, used popularly as vegetable, and as spice for its distinctive aroma, possessing medicinal values because of the bioactive compounds, with health-promoting properties.
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The current communication justifies the basis of usage of M. koenigii plants in traditional medicine in order to treat various disorders in humans. Curry leaves extracts might be utilized to synthesize SNPs providing an alternative eco-friendly method to chemical synthesis, and the SNPs thus formed can be more effective, than the silver ions/salts, antimicrobial agents decreasing the concentration of such toxic metals in therapeutic usage. Moreover, because of an array of several phytoconstituents in the plant with diverse bioactivity, curry plants can be exploited for plant-based therapeutic agents; however, more studies are needed on these issues.

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