Review Article

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

Shyamapada Mandal

Department of Zoology, Laboratory of Microbiology and Experimental Medicine, University of Gour Banga, Malda, West Bengal, India

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

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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.

Address for correspondence: Dr. Shyamapada Mandal, Department of Zoology, Laboratory of Microbiology and Experimental Medicine, University of Gour Banga, Malda - 732 103, West Bengal, India.
E-mail: samtropmed@gmail.com

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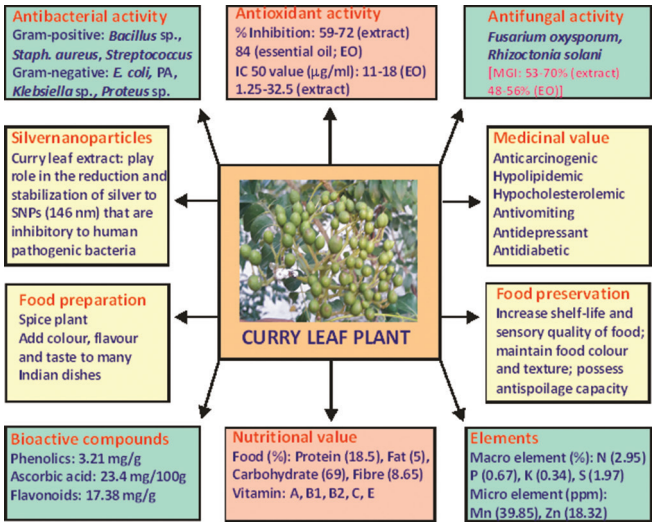

Figure 1: Schematic diagram showing usage and application of *Murraya koenigii* plant (Source: Vyas *et al*., Rajnikant *et al*., Gaikwad *et al*., Bonde *et al*., Sajeshkumar *et al*., Mishra *et al*., Rajendran *et al*., Khedkar, Sonia *et al*.).[19,25,32,40,45-49] MGI: Mycelial growth inhibition

Figure 2: *Murraya koenigii* plant: (a) Inflorescences, (b) twig bearing fruits, (c) fully opened flower and buds, (d) fruits morphology and color (Photographed by the author)

BOTANICALS

The *M. koenigii* L. is a shrub or a small tree [Figure 2], grows 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, saponins, quinones, alkaloids, flavonoids, tannins, carbohydrates, proteins, and volatile oils; the important alkaloids include mahanine, O-methyl murrayamine A, O-methyl mahanine, koenine, koenigine, koenidine, girinimbiol, bispyrayafoline, girinimibine, isomahanine, koenimbine, and 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

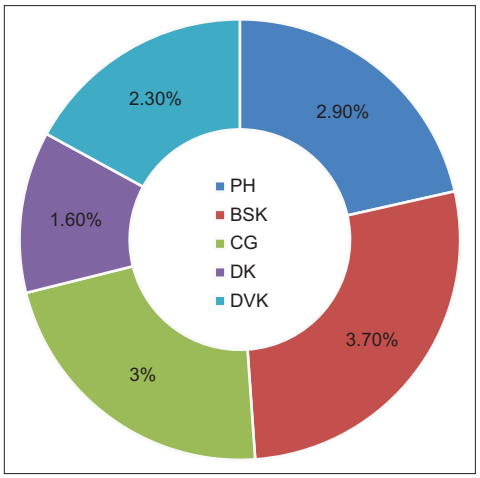

Figure 3: Yield of essential oils of curry leaves collected from various regions of Western Ghats, India hills (Source: Text data adapted from Syamasundar *et al.*);[12] BSK: Bisalakoppa, Sersi (Karnataka), CG: Chorla (Goa), DK: Dandeli (Karnataka), DVK: Door village (Karnataka), PH: Papanasam

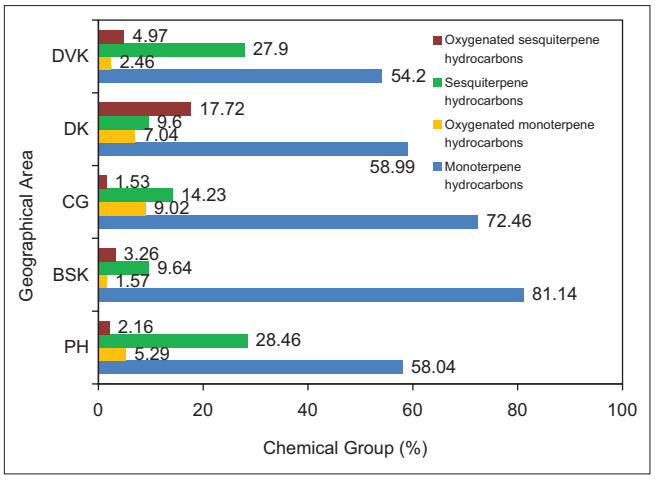

Figure 4: *Murraya koenigii* leaves chemotype: The contents of chemical groups (Source: Text data adapted from Syamasundar *et al.*);[12] BSK: Bisalakoppa, Sersi (Karnataka), CG: Chorla (Goa), DK: Dandeli (Karnataka), DVK: Door village (Karnataka), PH: Papanasam

stimulant as well as in body ache, whereas the bark is used in the treatment of snakebite.[14] 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 eruption while bark and roots are utilized as stimulants and applied to cure skin eruption and to bite of poisonous animals.[15] 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.[16]

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%).[15,17] 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.[18] 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*.[19] 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.[20]

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.[17]

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.[19] The radical scavenging capacity of three varieties of *M. koenigii* methanolic extracts was in the order of Gamthi > Dwarf > Regular, with IC_{50} 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: Euchrestine B, bismurrayafoline E, mahanine, mahanimbicine, and mahanimbine, which in 1,1-Diphenyl-2-picrylhydrazyl (DPPH) system had antioxidative activity in the order of bismurrayafoline E > euchrestine B and mahanine > mahanimbicine and mahanimbine while euchrestine 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 IC_{50} 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, mahanimbicine, and mahanimbine against Gram-negative and Gram-positive bacteria [Figure 5],[29] and the MICs of these alkaloids ranged 12.5–175 mg/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

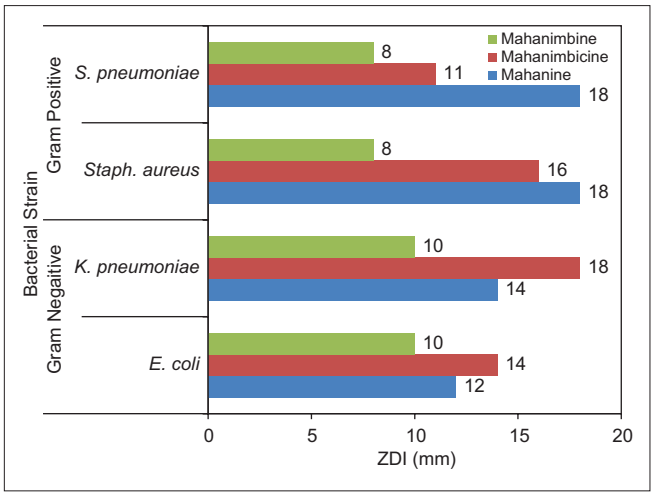

Figure 5: Antibacterial activity of curry leaf carbazole alkaloids against human pathogenic bacteria (Source: Data table partially converted from Nagappan *et al*.);[29] ZDI: Zone diameter of inhibition

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%).[25] 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

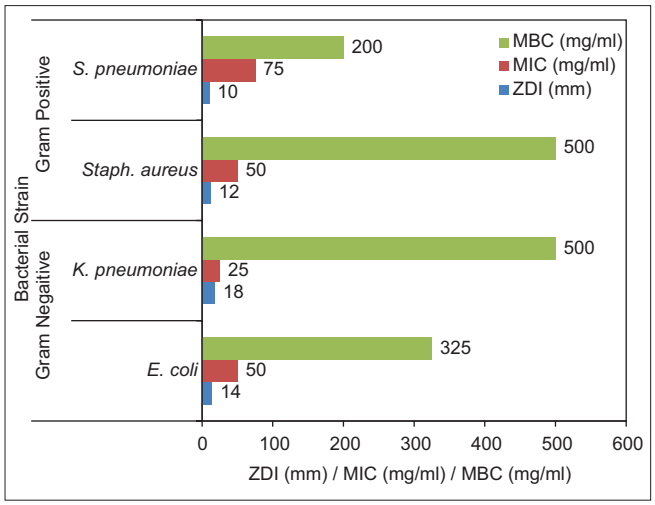

Figure 6: Antibacterial activity of essential oil from *Murraya koenigii* against human pathogenic bacteria (Source: Data table partially converted from Nagappan *et al*.);[29] ZDI: Zone diameter of inhibition, MIC: Minimum inhibitory concentration, MBC: Minimum bactericidal concentration

patterns), such as in meat and meat products during storage, making them unfit for consumption by humans; *M. koenigii* berry extract has been reported to be an excellent source of antioxidative compounds (tocopherol, β-carotene, lutein, flavonoids, and phenolics) to prevent oxidative damage of meat and meat products.[22] The curry leaves incorporated in functional poultry meat finger sticks improved lipid stability and antimicrobial quality of the products, indicating the effective use of *M. koenigii* as an alternative to synthetic food preservatives in functional meat food snacks, as per the report of Aswathi *et al*.[31]

MEDICINAL VALUES

The supplementation of curry leaves chutney had improved blood pressure levels (systolic: 147 mm Hg to 130 mm Hg vs. diastolic: 93 mm Hg to 83 mm Hg) among hypertensive subjects, as has been reported by Gaikwad *et al*.[32] The antidiabetic activity, weight loss, and cholesterol lowering effects of *M. koenigii* fruit juice have been reported by the earlier authors,[33,34] and it has been shown that the antidiabetic activity of *M. koenigii* leaves are possibly due to the presence of its antioxidant property.[35] The curry leaf extracts of Malaysian varieties with high levels of phenolic acids (especially Gallic acid) and flavonoids (especially myricetin, epicatechin, and quercetin) exhibited promising anticancer activity on MDAMB-231 human breast cancer cell line.[23] The abundantly available curry leaves in India can be utilized as the important source of medicine associated with healthy human life by curing many metabolic disorders as well as infectious diseases. The mice model study suggested the curry leaves extracts to be an important therapy in managing dementia as well as Alzheimer's disease.[36]

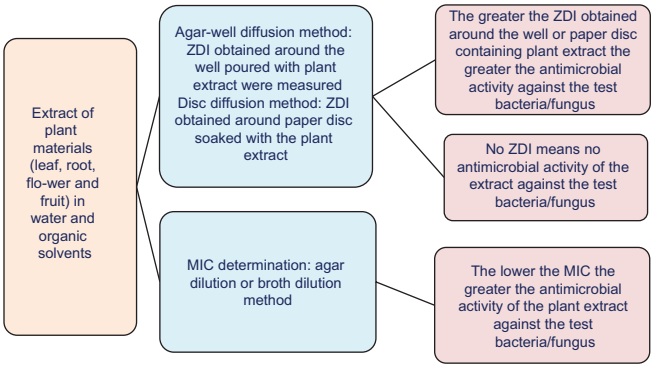

Figure 7: Schematic diagram showing antimicrobial activity of *Murraya koenigii* plant parts extracts against bacteria and fungus. MIC: Minimum inhibitory concentration, ZDI: Zone diameter of inhibition

GREEN SYNTHESIS OF SILVER NANOPARTICLES

Green synthesis of silver nanoparticles (SNPs) using plant extracts is an emerging field of research since such phytosynthetic method is simple, cost-effective, and eco-friendly, and like various medicinal and spice plants *M. koenigii* has the capacity to act as reducing agents of Ag^{+} to Ag^{0}, thereby forming SNPs that are fairly stable in solution and play a great role in nanomedicine.[37,38] Since ancient silver has been in use in its various forms such as silver nitrate, silver chloride, etc., in medicine to cure various diseases due to their bioactive properties. The SNPs are excellent antimicrobial agents and are 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*.[39] 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.[40] 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: Amphotericin and plant extract.[41] 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,

contained in it. As per the study carried out by Azzubaidi *et al*., the chronic LD_{50} for Malaysian curry leaf methanolic extract has been recorded as 200 mg/kg/day in rat model, the safest dose for long-term application with no toxic effect being 50 mg/kg/day.[42] The curry leaf extracts have been evaluated as nontoxic for normal cells as the IC_{50} values were >320 μg/ml, and ranged 334.5–377.2 μg/ml.[23] As investigated by Kalyani *et al*. the curry leaves extract was found safe at the dose of 2000 mg/kg, and the extract had hypotensive effect at 250 mg/kg and an antihypertensive effect at 150 mg/kg, however, the extract in combination with amlodipine showed an intense hypotensive effect, resulting in mortality of animals, even at reduced dosage (100 mg/kg of extract plus 250 μg/kg of amlodipine) in 2 weeks. Thus, curry leaves although possess potential medicinal properties, its dosage and the nature of interaction with other drugs are required to be determined *in vitro*, before therapeutic application.[43]

CONCLUSION

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.[44,45] 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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Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Mandal S, Mandal M. Coriander (*Coriandrum sativum* L.) essential oil: Chemistry and biological activity. Asian Pac J Trop Biomed 2015;5:930-7.
2. Mandal S, Pal NK, Mandal MD, Saha K. *In vitro* antibacterial activity of three Indian spices against methicillin resistant *Staphylococcus aureus*. Oman Med J 2011;26:319-23.
3. Mandal S, Mandal M. Fenugreek (*Trigonella foenum-graecum* L.) oils. In: Preedy V, editor. Essential Oils in Food Preservation, Flavour and Safety. London: Elsevier; 2015. p. 421-8.
4. Mandal M, Mandal S. Cumin (*Cuminum cyminum* L.) oils. In: Preedy V, editor. Essential Oils in Food Preservation, Flavour and Safety. London: Elsevier; 2015. p. 377-82.
5. Mitra E, Ghosh AK, Ghosh D, Mukherjee D, Chattopadhyay A, Dutta S, *et al.* Protective effect of aqueous *Curry leaf* (*Murraya koenigii*) extract against cadmium-induced oxidative stress in rat heart. Food Chem Toxicol 2012;50:1340-53.
6. Dhongade H, Sawarkar H, Muley B, Deshmukh V, Pande A. Therapeutic potentials of *Murraya koenigii* Spreng (*Rutaceae*). Indo Am J Pharm Res 2013;3:1-10.
7. Kamat N, Pearline D, Thiagarajan P. *Murraya koenigii* (L.) (Curry leaf): A traditional Indian plant. Res J Pharm Biol Chem Sci 2015;6:691-97.
8. Parul S, Javed A, Neha B, Honey J, Anuj B. Curry leaves – A medicinal herb. Asian J Pharm Res 2012;2:51-3.
9. Raina VK, Lal RK, Tripathi S, Khan M, Syamasundar KV. Essential oil composition of genetically diverse stocks of *Murraya koenigii* from India. Flavour Fragr J 2002;17:144-6.
10. Sivakumar CV, Meera I. Antioxidant and biological activities of three morphotypes of *Murraya koenigii* L. from Uttarakhand. J Food Process Technol 2013;4:246.
11. Kumar V, Suthar S, Bandyopadhyay A, Tekale S, Dhawan S. A review on traditional Indian folk medicinal herb: *Murraya koenigii*. World J Pharm Pharm Sci 2012;1:405-21.
12. Syamasundar KV, Srinivasulu B, Ananda PL. Chemo variations of wild curry leaf (*Murraya koenigii* Spreng.) from Western Ghats of India. J Pharmacogn 2012;3:126-30.
13. Gahlawat DK, Jakhar S, Dahiya P. *Murraya koenigii* (L.) Spreng: An ethnobotanical, phytochemical and pharmacological review. J Pharmacogn Phytochem 2014;3:109-19.
14. Kong YC, Ng KH, But PP, Li Q, Yu SX, Zhang HT, *et al.* Sources of the anti-implantation alkaloid yuehchukene in the genus *Murraya*. J Ethnopharmacol 1986;15:195-200.
15. Bonde SD, Nemade LS, Patel MR, Patel AA. *Murraya koenigii* (Curry leaf): Ethnobotany, phytochemistry and pharmacology – A review. Int J Pharm Phytopharmacol Res 2011;1:23-7.
16. Upadasa S. Curry Leaves. Pahana; 2014. Available from: http://www.pahana.com.au. [Last accessed on 2016 Feb 13]
17. Shanthala M, Prakash J. Acceptability of curry leaf (*Murraya koenigii*) incorporated products and attitude toward consumption. J Food Process Preserv 2005;29:33-44.
18. Bamishaiye EI, Olayemi FF, Awagu EF, Bamshaiye OM. Proximate and phytochemical composition of *Moringa oleifera* leaves at three stages of maturation. Adv J Food Sci Technol 2011;3:233-7.
19. Vyas VG, Kandoliya UK, Vidhani SI, Parmar HJ, Bhalani VM, Golakiya BA. Heavy metal deposition and phytochemical characterization of curry leaves (*Murraya koenigii*). Int J Curr Microbiol Appl Sci 2015;4:839-43.
20. Kale NV, More GS. Biochemical, antimicrobial and organoleptic analysis of curry leaves (*Murraya koenigii*). Plant Sci Feed 2014;4:6-9.
21. Tachibana Y, Kikuzaki H, Lajis NH, Nakatani N. Antioxidative activity of carbazoles from *Murraya koenigii* leaves. J Agric Food Chem 2001;49:5589-94.
22. Yogesh K, Jha SN, Yadav DN. Antioxidant activities of *Murraya koenigii* (L.) Spreng berry extract: Application in refrigerated (4±1°C) stored meat homogenates. Agric Res 2012;1:183-9.
23. Ghasemzadeh A, Jaafar HZ, Rahmat A, Devarajan T. Evaluation of bioactive compounds, pharmaceutical quality, and anticancer activity of curry leaf (*Murraya koenigii* L.). Evid Based Complement Alternat Med 2014;2014:873803.
24. Gupta S, Paarakh PS, Gavani U. Antioxidant activity of *Murraya koenigii* Linn. leaves. Pharmacologyonline 2009;1:474-8.
25. Rajnikant, Kumar S, Chatterjee A. Antioxidant and antifungal potential of *Murraya koenigii* leaves extracts (crude) and essential oil. Chem Sci Trans 2015;4:222-6.
26. Saini SC, Tyagi MK. Studies about *Murraya koenigii* (quality estimation and antibacterial and antifungal properties). Int J Pharm Sci Invent 2015;4:19-24.
27. Argal MS, Kumar S, Choudhary HS, Thakkar RM, Verma SK, Seniya C. The efficacy of *Murraya koenigii* leaf extract on some bacterial and a fungal strain by disc diffusion method. J Chem Pharm Res 2011;3:697-704.
28. Vats M, Singh H, Sardana S. Phytochemical screening and

antimicrobial activity of roots of *Murraya koenigii* (Linn.) Spreng. (*Rutaceae*). Braz J Microbiol 2011;42:1569-73.
29. Nagappan T, Ramasamy P, Wahid ME, Segaran TC, Vairappan CS. Biological activity of carbazole alkaloids and essential oil of *Murraya koenigii* against antibiotic resistant microbes and cancer cell lines. Molecules 2011;16:9651-64.
30. Selvamani S, Balamurugan S. Evaluation of the antimicrobial potential of various solvent extracts of *Murraya koenigii* (Linn.) Spreng leaves. Int J Curr Microbiol Appl Sci 2014;3:74-7.
31. Aswathi PB, Biswas AK, Beura CK, Yadav AS, Khatke PA. A study on the antimicrobial and antioxidant effects of *Murraya koenigii* on functional poultry meat finger sticks. Int J Meat Sci 2014;4:15-21.
32. Gaikwad P, Khan TN, Nalwade V. Impact of curry leaves (*Murraya koenigii*) chutney supplementation on hypertensive subjects. Int J Food Nutr Sci 2013;2:68-72.
33. Tembhurne SV, Sakarkar DM. Biochemical and physiological responses of fruit juice of *Murraya koenigii* (L) in 28 days repeated dose toxicity study. Int J Pharm Technol Res 2009;1:1568-75.
34. Tembhurne SV, Sakarkar DM. Hypoglycemic effects of fruit juice of *Murraya koenigii* (L) in alloxan induced diabetic mice. Int J Pharm Technol Res 2009;1:1589-93.
35. Tembhurne SV, Sakarkar DM. Protective effect of *Murraya koenigii* (L) leaves extract in streptozotocin induced diabetics rats involving possible antioxidant mechanism. J Med Plant Res 2010;4:2418-23.
36. Mani V, Ramasamy K, Ahmad A, Parle M, Shah SA, Majeed AB. Protective effects of total alkaloidal extract from *Murraya koenigii* leaves on experimentally induced dementia. Food Chem Toxicol 2012;50:1036-44.
37. Song JY, Kim BS. Rapid biological synthesis of silver nanoparticles using plant leaf extracts. Bioprocess Biosyst Eng 2009;32:79-84.
38. Philip D, Unni C, Aromal SA, Vidhu VK. *Murraya koenigii* leaf-assisted rapid green synthesis of silver and gold nanoparticles. Spectrochim Acta A Mol Biomol Spectrosc 2011;78:899-904.
39. Rai MK, Deshmukh SD, Ingle AP, Gade AK. Silver nanoparticles: The powerful nanoweapon against multidrug-resistant bacteria. J Appl Microbiol 2012;112:841-52.
40. Bonde SR, Rathod DP, Ingle AP, Ade RB, Gade AK, Rai MK. *Murraya koenigii*-mediated synthesis of silver nanoparticles and its activity against three human pathogenic bacteria. Nanosci Methods 2012;1:25-36.
41. Indhumathi T, Rajathi K. A study on synthesis of silver nanoparticles from *Murraya koengii* leaf and its antifungal activity. Int J Drug Dev Res 2013;5:293-8.
42. Azzubaidi MS, Saxena AK, Alattraqchi AG, Abdualkader AM. Chronic LD_{50} vs. safest dose for the methanolic extract of curry leaves (*Murraya koenigii*) cultivated in Malaysian. J Appl Pharm Sci 2014;4:56-8.
43. Kalyani HB, Ginpreet K, Aadesh K, Saloni D. The effect of *Murraya koenigii* extract on therapeutic efficacy of amlodipine in rats: Possible drug-herb interaction. Gen Med 2005;3:1000153.
44. Russell AD, Hugo WB. Antimicrobial activity and action of silver. Prog Med Chem 1994;31:351-70.
45. Sajeshkumar NK, Vazhacharickal PJ, Mathew JJ, Sebastin A. Synthesis of silver nanoparticles from curry leaf (*Murraya koenigii*) extract and its antibacterial activity. CIB Tech J Pharm Sci 2015;4:15-25.
46. Mishra A, Gupta V, Nagar H, Shrivastav V. Protective effect of *Murraya koenigii* (curry leaf) leaves extract against genotoxicity induced by cyclophosphamide in mouse bone marrow cells. Glob Vet 2013;10:128-33.
47. Khedkar RD. Curry leaf (*Murraya koenigii* L. Spreng) as a functional food. Food Sci Res J 2015;6:135-41.
48. Sonia NS, Mini C, Geethalekshmi PR. Effect of curry leaf application and packaging in enhancing shelf life of banana chips. Int J Trop Agric 2015;33:1127-33.
49. Rajendran MP, Pallaiyan BB, Selvaraj N. Chemical composition, antibacterial and antioxidant profile of essential oil from *Murraya koenigii* (L.) leaves. Avicenna J Phytomed 2014;4:200-14.