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Phytochemicals and Pharmacological Studies of *Murraya koenigii* Spreng (Rutaceae): A Comprehensive Review of its Therapeutic Potential

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ABSTRACT: The concept of "food as medicine and medicine as food" was prominent in ancient times, highlighting the therapeutic properties of plants. *Murraya koenigii*, also known as the "Magical plant of Indian Spice", not only served as a culinary ingredient but also held a vital place in traditional medicine among village and folk communities. It is a medicinal herb originating from India and has been extensively utilized in Ayurvedic medicine for centuries. The abundant presence of carbazole alkaloids in the roots, fruits, leaves, and bark of *Murraya koenigii* has been associated with their significant pharmacological activities, including anticancer, antidiabetic, antinociceptive, antibacterial, and antioxidant properties. Moreover, this plant retains a broad spectrum of biological events. The carbazole alkaloids such as koenigin, bicyclomahanimbicine, cyclomahanimbine, murrayastine, coumarine, koenidine and pyrayafoline carbazole has substantial medicinal activities. Given the phytochemistry and pharmacology of *Murraya koenigii*, there is a compelling need for a comprehensive review of its therapeutic potential as a valuable agent in the treatment and management of various human ailments. The present review incorporates the description, phytochemical constituents, and pharmacological activities of *Murraya koenigii.* The findings offer valuable insights into the potential development of effective drugs for the treatment of a wide range of ailments.

Keywords: *Murraya koenigii*, Phytochemistry, Pharmacological activities.

INTRODUCTION

Plants have long been a source of fulfillment for human needs, encompassing food, clothing, shelter, flavors, fragrances, and even medicines. Traditional medicinal practices such as Unani, Ayurveda, and Chinese medicine have advocated the use of plants as therapeutic agents. In fact, several important drugs in use today have originated from plant sources. The exhaustion of conventional approaches in drug discovery has prompted the adoption of ethnopharmacology and ethnobotany as navigational tools for uncovering new molecules from diverse sources and compound categories. The diversity of tropical plants plays a significant role in their ability to offer new leads and prospects (Gurib, 2006).

Hippocrates, often referred to as the father of Medicine, put forth the idea of "food is medicine and medicine is food" nearly 25-30 centuries ago. The plant being reviewed serves as a compelling example that justifies this principle (Bonde *et al*., 2011).

Murraya koenigii Spreng, belonging to the Rutaceae family, is referred to as "Surabhinimba" in Sanskrit. The leaves of this plant are known by different names among various ethnic groups. In Tamil, they are called "Karivempu", in Bengali as "Barsunga", and in Hindi as "Kurrypatte" (Anupam *et al*., 2010). It is part of a diverse group that includes over 150 genera and encompasses more than 1,600 species. Curry leaves are widely recognized as a popular spice and natural flavoring agent extensively utilized in Indian households for the preparation of delectable dishes. Originating from India, they are readily accessible year-round and have been incorporated into numerous Ayurvedic remedies since ancient times. Traditionally, people have relied on curry leaves not only to enhance the taste of food but also for their medicinal properties in treating various ailments.

Extensive research has been conducted on curry leaves, encompassing various aspects from stem to bark. This comprehensive review incorporates diverse ideas derived from multifaceted studies on curry leaves, aiming to enhance our understanding of both their therapeutic and non-therapeutic properties.

Since the start of the 21st century, there has been a growing fascination with exploring medicinal plants and their traditional applications across various regions (Giday *et al.*, 2009). Despite the availability of chemically synthesized drugs for numerous diseases, the significance of natural plant-based products remains intact, serving as a vital resource for the development of novel medications to address a wide range of ailments. *Murraya koenigii*, an herb of medicinal importance, is

currently under examination for its presence of phytochemicals and scientific relevance.

Morphological description

Three distinct morphotypes of *Murraya koenigii* exhibit variations in flavor intensity. The regular morphotype is characterized by rapid growth, visually appealing dark green leaves, and a bushy appearance. The dwarf morphotype grows as a shrub with spread branches, light green leaves, and possesses its unique aroma. The brown morphotype stands out as the most fragrant, featuring thick leaves with a smaller structure and a dark brown coloration (ChV *et al*., 2013; Gahlawat *et al*., 2014).

It is distributed across various regions in India and is cultivated in parts of the country such as Sikkim, Assam, and the Western Ghats. This tree species thrives in moist forests at elevations ranging from 500 to 1600 meters. It can be found in regions like S Hainan, Guangdong, S Yunnan, Sri Lanka, Nepal, Bhutan, Laos, Thailand, and Vietnam. Through the migration of South Indian communities, curry leaves have also reached countries like Malaysia, South Africa, and Reunion Island (Jain *et al*., 2012; Singh *et al*., 2014).

Table 1: Taxonomic classification.

Kingdom	Plantae
Subkingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Family	Rutaceae
Genus	Murraya J. Koenig
Species	*Murraya koenigii*

Traditional use

Fresh leaves, dried leaf powder, and essential oils derived from curry leaves are commonly employed to enhance the flavors of curries, fish dishes, soups, and meat-based preparations. They also add a delightful taste to egg dishes, serve as convenient ready-to-use seasonings, and contribute to the overall flavor profile of a wide range of culinary creations.

In Ayurvedic medicine, powdered dried curry leaf is combined with honey and betel nut juice to create an anti-periodic remedy. Externally, these leaves are applied to bruises, burns, eruptions, and bites from venomous creatures. Internally, they are employed to alleviate dysentery and manage diabetes mellitus. Furthermore, they function as a stimulant and have shown promise in treating conditions such as leucoderma, influenza, and rheumatism (Kamat *et al.*, 2015). Due to their bitter and acrid properties, both the leaves and roots exhibit cooling effects and possess anti-helminthic and analgesic properties. They are commonly used to treat piles, alleviate body heat, thirst, itching, and inflammation. The root juices have hepatoprotective properties and are known to be beneficial for kidney-related pains. Additionally, the fruits of this plant are highly nutritious and possess numerous medicinal properties (Sindhu and Arora 2012). In addition to their culinary applications, the essential oils obtained from curry leaves are also valued by the cosmetic, aromatherapy, and soap industries for their aromatic properties (Singh *et al.*, 2014). The steam distillates of the leaves are used as stomachic, carminative, purgative, febrifuge and anti-anemic (Parul *et al.*, 2012).

The leaves of *Murraya koenigii* are highly regarded as an excellent hair tonic, promoting the maintenance of natural hair texture and stimulating hair growth. A traditional method involves cooking the leaves with coconut oil until a concentrated residue is obtained. The various parts of the plant, including leaves and the entire plant itself, have been used in traditional remedies for their anti-emetic, blood purifying, depressant, antifungal, pain-relieving, anti-inflammatory, and anti-diarrheal properties. They have also been employed for alleviating kidney pain, vomiting, and treating poisonous animal bites. Consumption of raw green leaves of this plant aids in managing diarrhoea and morning sickness when combined with lime juice. Furthermore, applying a paste of the leaves or the juice of the roots can provide relief from boils and renal pain, respectively (Adebajo *et al*., 2005; Ponnusamy *et al*., 2010).

Phytochemistry

Mature curry leaves have a moisture content of 63.2%, nitrogen content of 1.15%, carbohydrate content of 14.6%, and total ash content of 13.06%. These leaves contain bioactive constituents such as oxalic acid, resin, carbazole alkaloids, and important compounds like koenigine, cyclo mahanimbine, murrayastine, coumarin, bicyclo-mahanimbicine, koenidine, and pyrayafoline-carbazole. These compounds exhibit significant pharmacological activities. The volatile oil present in curry leaves is mainly composed of bicyclo-mahanimbicine and mahanimbicine (Kureel *et al*., 1970; Nishan and Subramanian 2015).

In the study conducted by Prakash and Natarajan (1974), the presence of constituents such as Caryophyllene, alpha-pinene, and beta-pinene was identified in the leaves of *Murraya koenigii*. Mukonicine, a carbazole alkaloid, was isolated from the leaves of *Murraya koenigii* (Mukherjee *et al.,*1983). Through the application of physical methods and chemical evidence, the structure of mukonicine was determined to be 1,2-[2:2-dimethyl-Δ3-pyrano]-3-methyl-6,8-dimethoxycarbazole.

The bark of *Murraya koenigii* is a source of carbazole alkaloids, including Murrayazolidine, Murrayacine, mahanimbine, koenioline, girinimbine, and xynthyletin. On the other hand, the fruits of the plant typically contain reducing sugars, small amounts of acids and tannins, in addition to being a source of Vitamin C.

Major constituents in Curry plant

Mahanine- Mahanine, scientifically known as 3,11-dihydro-3,5-dimethyl-3-(4-methyl-3-pentenyl)-pyrano[3,2a] carbazol-9-ol, is a prominent carbazole alkaloid (Fig. 1). It is a significant component found in *Murraya koenigii*.

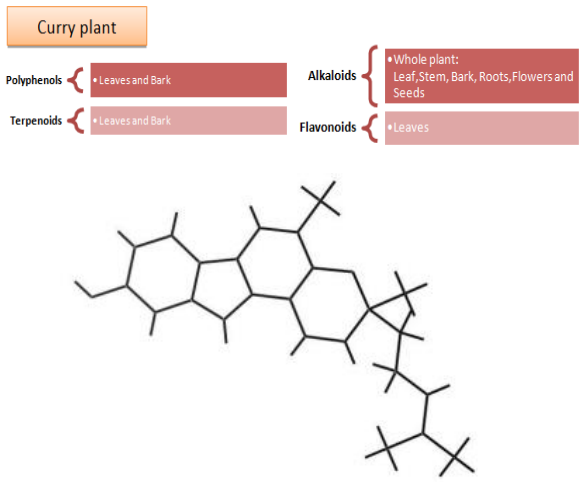

Fig. 1. Structure of Mahanine.

According to a study conducted by Roy *et al.* (2005), mahanine demonstrates a suppressive effect on cell proliferation and induces apoptosis in tumor cells (U937) (Roy *et al.*, 2005). The researchers performed two separate experiments to investigate the impact of mahanine on cell viability. In the first experiment, they exposed the cells to varying concentrations of the alkaloid for approximately 12 hours. In the second experiment, the cells were treated with 8.5 mM of mahanine for different durations. It was observed that up to a dose of 5 mM, mahanine did not exhibit any noticeable effect on cell viability or apoptosis even after 12 hours of treatment. However, as the concentration increased, there was a decline in cell viability accompanied by an increase in apoptosis (Roy *et al.*, 2005).

Girinimbine- Girinimbine, classified as a carbazole alkaloid, is believed to exhibit effects on angiogenic activity and induce apoptosis in tumor cells. Its IUPAC formula is 3,3,5-trimethyl-11H-pyrano[3,2-a] carbazole. The compound's structure is depicted in Fig. 2. Iman *et al.* (2015), conducted a study that revealed girinimbine's inhibitory effects on the growth and proliferation of HUVECs (human umbilical vein endothelial cells).Treatment of HUVECs and CCD-841 human colon epithelial cells with girinimbine led to a non-selective cytotoxic effect on both cell types. When exposed to seven different concentrations of girinimbine spanning from 1.5 µg/ml to 100 µg/ml, a dose-dependent inhibition of HUVEC proliferation was observed.

Additionally, Mohan *et al.* (2013), documented a selective and dose-dependent inhibition of A549 cells upon treatment with girinimbine. Following a 24-hour treatment, various morphological alterations were observed, such as cell shrinkage, ruffling, and blebbing of the cell membrane. These changes served as indications of the impact of girinimbine on A549 cells (Mohan *et al.*, 2013).

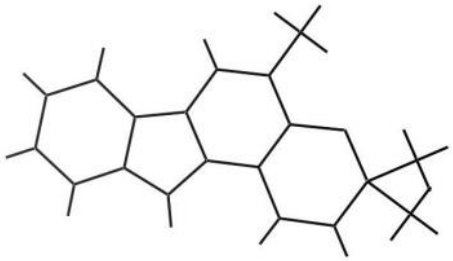

Fig. 2. Structure of Girinimbine.

Murrayanol- Murrayanol, with the IUPAC name 1-[(2E)-3,7-dimethylocta-2,6-dien-1-yl]-7-methoxy-6-methyl-9H-carbazol-2-ol, is represented by its structure shown in Fig. 3. According to Ramsevak *et al.* (1999), murrayanol exhibits anti-inflammatory activity. The compound demonstrated a half inhibitory concentration of 109 µg/ml in hPGHS-1 (human prostaglandin synthase-1) and 218 µg/ml in hPGHS-2 (human prostaglandin synthase-2). In addition to its anti-inflammatory properties, murrayanol has also shown mosquitocidal, topoisomerase I and II inhibition, and antimicrobial activities.

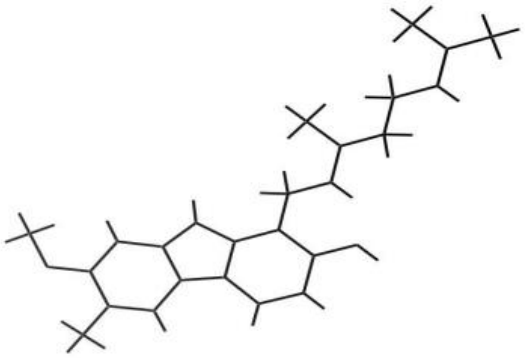

Fig. 3. Structure of Murrayanol.

Mahanimbine- Mahanimbine, with the chemical formula 3,5-dimethyl-3-(4-methylpent-3-enyl)-11H-pyrano[3,2-a]carbazole, is depicted in Fig. 4. According to the findings of Mitra and Mahadevappa, (2010), the intraperitoneal administration of mahanimbine at concentrations of 50 mg/kg and 100 mg/kg exhibited both antidiabetic and hypolipidemic effects in diabetic rats. The study conducted by Mitra and Mahadevappa, proposed that the mechanism of action of mahanimbine is similar to that of glibenclamide, a standard drug used for diabetes treatment. Furthermore, mahanimbine exhibited significant cytotoxic effects against several cancer cell lines. The half inhibitory concentration (IC50) values were determined as 2.12 µg/ml for MCF-7, 5.00 µg/ml for P388, and 1.98 µg/ml for Hela cell lines. In addition, mahanimbine demonstrated reduced susceptibility to antibiotic-resistant bacteria, as evidenced by its zone of inhibition ranging from 8 mm to 10 mm. (Nagappan *et al.*, 2011).

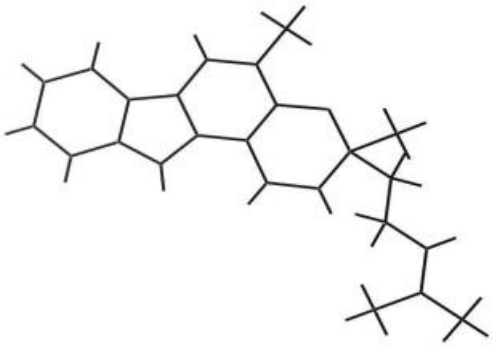

Fig. 4. Structure of Mahanimbine.

Ramsewak *et al*. (1999), reported the antioxidant activity of mahanimbine, with an IC50 value of 33.1 µg/ml, using fluorescence spectroscopy analysis in a liposome oxidation model. The alcohol-water (1:1) extract of *Murraya koenigii*, where mahanimbine is derived from, exhibited the highest antioxidant activity and demonstrated effective scavenging of free radicals. The extract showed a reduction in cytochrome C and ferric ion levels, chelation of ferrous ions, and inhibition of ferrous sulfate: ascorbate-induced fragmentation and sugar oxidation of DNA (Ramsevak, 1999; Jain *et al.*, 2012).

Koenimbine

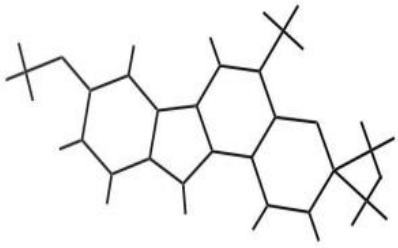

Fig. 5. Structure of Koenimbine.

Koenimbine, classified as a carbazole alkaloid (Fig. 5), is known by its IUPAC name 3,11-Dihydro-8-methoxy-3,3,5-trimethylpyrano[3,2-a] carbazole. In experiments involving rats, oral administration of koenimbine demonstrated dose-dependent control of diarrhea. A dosage of 30 mg/kg of koenimbine exhibited a similar effect to that of the standard drug diphenoxylate administered at a concentration of 5 mg/kg. Notably, a dosage of 50 mg/kg of koenimbine displayed a more pronounced effect compared to the 5 mg/kg dosage of the standard drug (Mandal *et al.*, 2010).

Koenigine- Koenigine, represented by its IUPAC name 8-Methoxy-3,3,5-trimethyl-3,11-dihydropyrano[3,2-a] carbazol-9-ol (Figure 6), was investigated by Rao et al for its antioxidant properties. In comparison to Butylated hydroxy anisole (BHA), which exhibited an antioxidant activity of 92% at a concentration of 0.556 mM, koenigine displayed a slightly lower activity of 84% at a concentration of 0.324 mM. However, despite the slightly lower activity, koenigine was identified as a potent radical scavenger, demonstrating significant antioxidant capabilities (Rao *et al*., 2007).

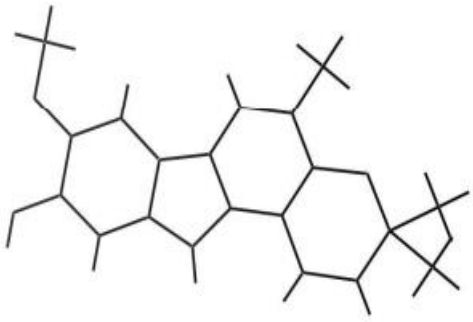

Fig. 6. Structure of Koenigine.

Murrayazoline- Murrayazoline, with the IUPAC name (14R, 17S)-3,13,13,17-Tetramethyl-21-oxa-12-azahexacyclo [10.7.1.12,17.05,20.06,11.014,19] henicosa-1(20),2,4,6,8,10-hexaene (Fig. 7), was investigated by Wu *et al.* (1998) for its potential antiplatelet aggregation activity and vasorelaxant effects. The compound exhibited significant inhibitory effects on platelet aggregation induced by various chemicals, such as arachidonic acid, collagen, and PAF, in rabbit models.

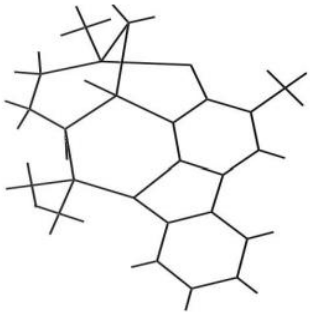

Fig. 7. Structure of Murrayazoline.

Pharmacological studies

Anti-bacterial activity. The antimicrobial properties of the essential oils derived from *Murraya koenigii* leaves were observed to be effective against various bacteria including *Corynebacterium pyogenes*, *Streptococcus aureus*, *Bacillus subtilis*, *Pasteurella multocida*, and *Proteus vulgaris*. Remarkably, the oil exhibited antibacterial activity even when diluted at a ratio of 1:500. When the fresh curry leaves were extracted using acetone and separated into fractions, bioactive compounds such as murrayanol, mahanine, and mahanimbine were identified (Nutan *et al.*,1998).

In another, the antibacterial activity of *Murraya koenigii* leaves was investigated using ethanol extraction. The experiment focused on testing the activity against various bacterial strains including *Staphylococcus*, *E. coli*, *Streptococcus*, *Proteus*, *Klebsiella pneumonia*, and *Pseudomonas aeruginosa.* Notably, a clear zone of inhibition was observed for all strains except *Klebsiella pneumonia and Pseudomonas aeruginosa.* The effectiveness of the inhibition was comparable to antibiotics such as Amikacin and Gentamycin (Al *et al.*, 2016). The volatile oil derived from *Murraya koenigii* displayed effectiveness against *Staphylococcus epidemidis*, *S. aureus*, and various *Streptococcus species*. However, the aqueous extract of

the plant did not demonstrate the same level of activity (Akerele and Ayinde 1998).

Table 2

Pharmacological activity	Plant Part	Extract
Analgesic and Antinociceptive	Leaf	Methanol
Anti-amnesic	Leaf	Petroleum ether
Anti-bacterial	Bark, Leaf	Petroleum ether and Alcohol
Anti-cancer	Bark, Stem	Petroleum ether
Anti-diabetic	Whole plant, fresh leaf, fruit	Aqueous and Methanol
Antidiarrhoeal	Seeds	n-Hexane
Anti-fungal	Leaf	Alcohol,Acetone, Petroleum ether
Anti- inflammatory	Leaf	Ethanol, Petroleum ether, Chloroform, methanol
Anti-helminthic	Leaf	Alcoholic
Anti-lipid peroxidative	Leaf	Methanol
Anti-oxidant	Leaf	Methanol and Aqueous
Anti-tumor	Leaf	Petroleum ether
Anti-ulcer	Leaf	Aqueous
Cardiovascular	Leaf	Aqueous
Cytotoxicity	Stem, Roots	Aqueous
Hypocholesterolemic	Leaf	Ethanol
Memory enhancer	Leaf	Petroleum ether
Phagocytic activity	Leaf	Methanol
Wound healing activity	Leaf	Ethanol

Anti-fungal activity

The extracts derived from *Murraya koenigii* leaves were found to exhibit antifungal activity against various fungi, including *Candida tropicalis*, *Candida albicans*, *Aspergillus fumigatus*, *Aspergillus niger*, and *Microsporum gypseum.* Furthermore, the alcoholic extract of the leaves demonstrated fungitoxicity against *Rhizoctonia solani* and *Colletotrichum falcatum* (Kishore *et al.,* 1982). The efficacy of methanolic and ethanolic extracts from *Murraya koenigii* was observed against the mycelial growth of *Rhizoctonia solani* and *Fusarium oxysporum*, albeit with varying degrees of effectiveness. Both extracts showed inhibitory effects on the growth of the fungi, but their efficiencies differed (Rajnikant *et al.,* 2015).

Anti-cancerous activity

Carbazole and girinimbine, extracted from the bark of *Murraya koenigii*, have been found to induce programmed cell death in HepG2 cells. A study conducted by Bhattacharya *et al.* (2010) provided evidence suggesting the involvement of the death receptor-mediated extrinsic pathway of apoptosis through mahanine. Mahanine exhibited anti-cancer activity in MOLT-3 cells but did not produce the same effect in K562 cells (Bhattacharya, 2010). Additionally, pyrayafoline, murrafoline, and three carbazole alkaloids demonstrated significant activity against HL-60 cells (Noolu *et al*., 2013). The research supports mahanine as the primary bioactive molecule with anti-cancer properties in *M. koenigii* (Samantaa *et al.,* 2018). Amna *et al*., 2019, conducted a study demonstrating the cytotoxic effects of *Murraya koenigii* leaves against HeLA cancer cell lines. Furthermore, similar research has been conducted on animal models to investigate the effects of leaf extracts on intestinal and colon cancer (Khan *et al.,* 1996).

Anti-oxidant. Among various leafy vegetables, *M. koenigii* leaves exhibited the highest antioxidant potential, surpassing four other types of leafy vegetables. This highlights the significant presence of antioxidants in *Murraya koenigii*, contributing to its potential health benefits (Gupta and Prakash 2009). The research findings indicate that the aqueous extracts of *Murraya koenigii* leaves demonstrated a noteworthy protective mechanism against cadmium-induced damage to the cardiac tissues of rats (Mitra *et al.,* 2012).

The potential of *Murraya koenigii* to alleviate the gastric damage induced by Piroxicam, a medication used in the treatment of arthritis, was demonstrated by conducting experiments on rats. The study involved inducing gastric ulcers in the rats and subsequently treating them with *Murraya koenigii* (Firdaus *et al.,* 2014). In experimental animals, it has been observed that the benzene fraction of *Murraya koenigii* possesses both antioxidant and antimutagenic properties (Zahin *et al.,* 2013).

Anthelmintic activity

The anthelmintic activity of alcoholic and hot aqueous extracts obtained from *Murraya koenigii* leaves was evaluated against *Pheretima posthuma*. At a concentration of 100 mg/mL, both extracts exhibited significant activity. However, it was observed that the ethanolic extract demonstrated higher anti-helminthic activity compared to the petroleum ether extract (Pagariya *et al.,* 2013).

The extract derived from *Murraya koenigii* was assessed for its efficacy against *Haemonchus contortus*, a gastrointestinal nematode that affects sheep. The crude methanolic extract demonstrated 100% mortality of adult worms within eight hours of exposure (Molla and Bandyopadhyay 2016).

Anti-ulcer. The anti-ulcer activity of the hot aqueous extract derived from *Murraya koenigii* leaves was investigated at doses of 250 and 400 mg/kg. The extract demonstrated inhibition of gastric lesions induced by

non-steroidal anti-inflammatory drugs and pylorus ligation in a model study. It effectively reduced gastric volume, ulcerative lesions, and levels of free and total acidity. Additionally, an increase in the pH value of gastric juice was observed in the pylorus ligation model. These findings indicate that the extract possesses noteworthy anti-ulcer activity (Sharma *et al.,* 2011).

Anti-diarrheal activity

Murraya koenigii has been traditionally used for ages as a remedy for diarrhea, as documented in Ayurvedic literature. Experimental studies have also provided significant evidence supporting its effectiveness. Notably, it exhibited inhibitory activity against castor oil-induced diarrhea in rats. The bioactive compounds, namely koenimbine, carbazole, and kurryam, obtained from the fractionated n-hexane extract of *M. koenigii* seeds, demonstrated activity against diarrhea and gastrointestinal motility in rats, as observed in the charcoal meal test (Rana *et al*., 2004; Sharma *et al*., 2012; Ramasamy *et al.,* 2016).

Cardioprotective activity

Several studies have been conducted to confirm the cardioprotective properties of *Murraya koenigii*. Among these studies, one focused on the use of a hot aqueous extract of *M. koenigii* leaves to treat rat cardiac muscles affected by cadmium-induced oxidative stress. The infusion of cadmium in rats resulted in alterations in the activities of mitochondrial Kreb's cycle and respiratory chain enzymes. However, when the rats were pre-treated with the hot aqueous extract of *M. koenigii*, improvements were observed in all these aspects, indicating the potential of the extract as a cardioprotective agent (Kadam *et al*., 2011).

An additional experiment focused on the cardiotoxicity caused by doxorubicin, a drug known to potentially lead to irreversible congestive heart failure. A dose-dependent study was conducted, revealing that the extract derived from *Murraya koenigii* leaves contains a high concentration of flavonoids and phenols, which have the potential to act as free radical scavengers. The study yielded positive results, suggesting the cardioprotective effects of the extract (Phatak and Matule 2016). Furthermore, Phatak and Matule proposed an idea to investigate the cytotoxicity induced by lead, which can result in hematological, physiological, and biochemical alterations in the body and potentially lead to Ischemic Heart Disease. Differences were observed in thrombocyte indices, such as platelet count (PLT) and platelet-large cell ratio (P-LCR), and the role of antioxidants present in the leaves was observed as a potential chelating agent for lead.

Hypocholesterolemic activity

The plant leaves' ethanolic extract contains important phytochemical compounds called Carbazole alkaloids, which have shown potential in treating and curing various diseases. Additionally, the ethanol extract has demonstrated a hypocholesterolemic effect, meaning it can lower cholesterol levels. This effect was studied in elderly mice, where researchers observed a reduction in cholesterol levels. Interestingly, the study found that a dose of 500mg/kg of the extract was more effective in reducing cholesterol compared to the commonly used hypocholesterolemic drug simvastatin (Singh *et al*., 2016).

Mosquitocidal and larvicidal activity

In a study conducted by Das et al., the toxic effects of mahanimbine on *Culex quinquefasciatus* larvae were observed, contradicting its previous assumptions. Additionally, the petroleum ether and acetone extracts derived from *Murraya koenigii* leaves were found to possess larvicidal properties against *Aedes aegypti* mosquitoes (Harith *et al*., 2018). Strong activity against *Aedes aegypti*, the mosquito responsible for transmitting dengue fever, was observed in the chloroform and methanol extracts obtained from the stem bark of *Murraya koenigii* (Sukari *et al.,* 2013).

Effect on dental caries

The traditional practice of using *Murraya* leaves for treating dental problems has been observed since ancient times. In experimental studies conducted on golden hamsters, it was noted that feeding the hamsters with Murraya leaves and extracts resulted in beneficial effects. Active ingredients such as Isomahanine, Murrayanol, and Mahanine were identified in these leaves. Considering these findings, the utilization of Murraya leaves in products such as toothpaste, oral gargles, and chewing gums could be explored as a preventive measure against oral problems and dental caries (Keishiro *et al*., 1996).

Uses as cosmetics

The leaves of *M. koenigii* have been traditionally used as a skin disinfectant, where bathing with lukewarm water infused with leaf extracts is believed to alleviate skin infections. Moreover, the potential of these leaves in the field of cosmetics has been recognized. They have been found to possess skin-lightening and moisturizing properties due to the presence of antioxidants and hyaluronidase inhibitory activity. Formulations incorporating these herbal properties have been tested in creams, demonstrating improvements in skin lightening and texture. Furthermore, research has also focused on the sun protection activity of *M. koenigii* leaves, suggesting their potential to enhance natural pigmentation and serve as additives in cosmetic products (Tsuneo *et al.,* 1995).

CONCLUSIONS

The available literature on *Murraya koenigii* highlights its abundance of bioactive phytochemicals that have shown potential in treating various diseases. With its widespread presence in India, *M. koenigii* holds significant appeal for further exploration through pre-clinical and clinical research. This multipotential medicinal plant offers a wide range of applications, as different parts of the plant possess medicinal properties and are utilized in traditional medicine. Extensive examination of its bioactivity, pharmacotherapeutics,

mechanisms of action, toxicity profiles, and proper standardization, coupled with clinical trials, may pave the way for the development of new drugs. The plant is commonly employed for its stimulant, antiemetic, antiperiodic, antidiarrheal, tonic, antifungal, depressant, blood-purifying, and anti-inflammatory properties.

Moreover, *Murraya koenigii* has gained recognition for its efficacy in addressing a range of ailments, including body aches, diabetes mellitus, vomiting, stomachic issues, leucoderma, kidney pain, and fevers. It also serves to stimulate appetite and aid digestion. The plant harbors a diverse assortment of phyto-constituents, encompassing carbazole alkaloids, coumarin, carotenoids, carbazole carboxylic acid, lipids, and essential oils. With its validation of numerous traditional uses, future directions may encompass clinical trials and the development of formulations, employing a comprehensive approach to elucidate its therapeutic properties. Furthermore, investigating geographical and seasonal variations could unveil the specific chemical constituents responsible for its bioactivity, offering an intriguing avenue for research. Undertaking extensive research and development endeavors concerning the plant and its derivatives holds pivotal importance in optimizing therapeutic efficacy and fostering economic utilization.

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