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Review

Unveiling the diverse medicinal properties of *Murraya koenigii*

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Abstract: Since the beginning of time, nature has provided medicines for treating fatal illnesses. Herbalists believe that certain plants have medicinal qualities. In tribal and rural communities, medicinal plants provide as an easily accessible source of treatment. The identification of various rejuvenating molecules that can halt or lessen the pathology of a variety of diseases will be regarded as a significant development of the present. There has been a scientific advancement in this area, and current studies on herbal medicines and traditional cures have attracted significant interest from all over the world. This plant, popularly known as the curry tree, is frequently used as herb and is also used to treat a variety of problems in traditional Indian medicine. About 80–85% of people worldwide rely on herbal products because they are thought to be efficient, secure, and cost-effective. Reviewing the plant taxonomy, ethnobotanical characteristics, folkloric or traditional uses, phytochemical, and pharmacological qualities of the *Murraya koenigii* plant was the goal of the current study. The leaves are used internally for dysentery as a carminative, tonic, stomachic, and inducer of vomiting. The usage of other parts includes treating piles, preventing helminthiasis, and reducing body heat, itchiness, and inflammation. Following several reports that this plant may treat a wide range of illnesses, scientists have worked to confirm the effectiveness of this plant by biological screening. A review of the literature suggests that *Murraya koenigii* has various medical benefits, including activity of antimicrobial, cardiac, anti-oxidative, anti-diabetic and cholesterol reduction, cytotoxic action, antiulcer, and anti-diarrhea.

1. Introduction

India is the habitat to more than 50,000 plant species, the majority of which are employed in folk and traditional herbalism. Many medicinal plants are used directly to treat illnesses or heal wounds, while some natural or pure compounds are consumed every day as a source of vital nutrients (1). For his basic requirements, such as food, clothing, and shelter, man uses plants in a variety of ways. For both urban and rural cultures, wild plants are the primary source of medicines, crafts, and cosmetics (2). Additionally, in rural regions, plants are the primary employers and sources of income (3). Plants have been utilised as remedies for thousands of years all across the world. According to WHO, around 80% of the population still relies on plant-based medications for primary care, especially in underdeveloped Nations. Siddha, Unani, Ayurveda, and indigenous health civilizations are just a few of the medicinal systems used in India; they all make extensive use of herbs to cure human and animal illnesses (4). These therapeutic plants are crucial to us in another manner as well. India has a great variety of natural resources and a successful track record of traditional or old-style medicines; a sizable portion of the population still relies on plant-based medications

for primary healthcare (5). The uses of medicinal plants are not only economical, but they also come with few or no adverse effects. *Murraya koenigii*, commonly known as Curry, Kadi, Kari Patta, or Mitha Neem, is one such plant that is well-known in many nations, including India (6). *Murraya koenigii* is a native of Sri Lanka and India and is a member of the Rutaceae family. Curry leaves are a common ingredient in south Indian cuisine and have been used to flavor food for a very long time. Utilizing medicinal plants has little to no negative effects and is also cost-effective. One such plant, *Murraya koenigii*, is well-known in many countries, including India. It is also known by the common names Curry or Mitha Neem. Curry leaves are a common ingredient in south Indian cuisine and have been used to flavour food for a very long time (7). Vitamins A, B, C and E are abundant in this plant. Curry leaves are a good source of folic acid and iron, which fight anaemia (8). Curry leaves include a variety of phytochemicals that prevent cancer, treat liver damage, have neuro-protective capabilities, and fight against issues with the stomach, mouth, heart, and other organs (4, 8).

Various names have been given to *Murraya koenigii*, including Karepaku in Andhra Pradesh, Kartaphulli in Bengal, Curry/Kari Patta in Hindi, and Curry Leaf in English. Karivempu in Tamilnadu, Kathnim and Karibevu in Karnataka, Narasingha in Assam, Gani, Gandhela and Gandla in Uttarakhand, Mitha Neemin Himachal Pradesh, Kariveppilei in Kerala, and Bhursangain from Orissa; Pindosine from Burmese; Gorenimbin, from Gujarat; Kerriebladeren from Dutch; Karrry bald, from Danish; Curryblatter, from German; Daunkari, from Indonesia; Feuilles de curry from French; Hoja, from Spanish; and Fogli de Car, from Italian (Table 1). *Murraya koenigii* is one of the therapeutically significant herbs, and its taxonomy, ethnobotany, traditional use, and scientific significance are being evaluated (8). Therefore, the present review will describe and cover prior and current key works on *Murraya koenigii* linked to the themes chosen rather than covering a small number of carefully chosen studies over a short period of time. The information will be methodically sorted, contrasted, and summarised, including phytochemical screening, identification, and pharmacological activity. We predicted that all of these efforts would result in a useful synthesis of pharmacological activity that would start off future views in the clearest possible way.

Table 1. Vernacular names of *Murraya koenigii* (8, 9, 10, 11).

Language	Commonly Known as
English	Curry leaves
Hindi	Karipatta,Mithanim
Bengali	Kartaphulli
Kannada	Karibevu
Gujarathi	Mitholimado
Tamil	Kariveppilai
Malayalam	Kariveppu
Marathi	Kadhilimb
Sanskrit	Girinimba
Telugu	Karepeku
Tulu	Bevusoppu
Portuguese	Folhas de caril
Russian	Listya karri
Spanish	Hojas de curry
Italian	Fogli di Cari
French	Feuilles de Cari
German	Curryblatter

2. Taxonomy of plant kingdom

Murraya koenigii, a member of the Rutaceae family and commonly referred to as a "curry-leaf" tree, is a native of Sri Lanka, India, and other south Asian nations (10). It is native to practically all of India and has a distinctive perfume. It is a deciduous tree or shrub that may grow up to 6 meter tall and have trunk diameters of 15 to 40 cm with thin, smooth, brown or grey bark. (12). This plant's majority of parts emit a potent, off-putting odour. A species of tree known as *Murraya koenigii* is indigenous to the Asian tropical region, which extends from the Indian Himalayan foothills to Sri Lanka, via Indonesia, Myanmar, Southern China, and Hainan. The curry tree has bipinnately complex leaves that are 15–30 cm long, each carrying 11–25 leaflets alternate on rachis, and 2.5–3.5 cm long ovate lanceolate leaves.

The curry tree has grey colour bark with longitudinal striatations, and beneath it, white colour bark is visible (13). Bisexual, funnel-shaped, white, sweetly scented, complete, stalked, irregular flowers with 2-3 mm long petioles and irregular edges have an average diameter when fully opened. 12 cm long terminal cymes with 60–90 blooms each. The ovoid, rough, or wrinkled fruits have glands, (Table 2) (10, 13).

Table 2. *Murraya koenigii*'s plant taxonomy (8, 10, 11).

Kingdom	**Plantae**
Subkingdome	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Order	Sapindales
Family	Rutaceae
Genus	*Murraya.Koenigii ex L.*
Species	*Murraya koenigii L.*

3. Ethnobotanical use of *Murraya koenigii*

In Eastern Asia *Murraya koenigii* has countless important uses in the traditional system of medicine. Based on ethno-medicine, it is used as an anti-dysentric, anti-diabetic and stimulant (14). In Indian this plant is extremely valued for its leaves as an important ingredient to promote digestion and appetite. The leaves, roots and barks are tonic, carminative and stomachic (15). Leaves are used in dysentery also check vomiting. Steam distillate of leaves can be used as anti-anaemic, febrifuge stomachic and purgative.

Externally leaves are applied to eruption and bruises. The leaves, roots are bitter in test, acrid, cooling, analgesic, anti-helminthic, allays heat of the body, thirst, itching and inflammation, it also cures piles (16, 17). Leuco-derma and blood diseases can both benefit from it. To stop vomiting, use the toasted leaves. Root juice is beneficial for treating kidney-related discomfort. Fruits are regarded as astringent in Indo-China (18). Crushed leaves are applied topically to treat skin eruptions and soothe burns. To cure snake bites from deadly animals, leaf pastes that have been crushed are administered. For flavouring curries, egg, meat, and fish meals, traditional curry powder, etc., people mostly utilise fresh leaves, dried leaf powder, and essential oil (19). To create cosmetics and soaps, the aromatherapy sector uses essential oils (20). The nutritional value of the fruits

is very high. The branches of this plant are frequently used as datun to clean teeth. In Table 3, the ethnobotanical profile is presented.

Table 3. Ethnobotanical use of *Murraya koenigii*.

No.	Used plant parts	Folk/ Ethnobotanical uses	References
1.	Leaves	Anti-anaemic, Anti-helminthic, Analgesic, Anti-ulcer, Anti-nociceptive Anti-amnesic, Anti-inflammation, cooling and itching, Stomachic, Purgative, Febrifuge, Hair tonic Stimulant of hair growth, Night blindness, Vomiting, Bruises and Eruption, Bites of poisonous animals, Hypercholesterolemia lightening, maintaining the natural skin, enhancing memory, lighting and rough skin improving, Pigmentation and showed skin, help to weight loss, to Enhance Appetite and digestion	(21, 22, 23)
2.	Whole plant	Stimulant, Blood-purifier, Hair tonic, Antidepressant, Anti-dysenteric, Antidiarrheal, Antifungal, Anti-inflammatory, Antiemetic, Febrifuge, Stomachic, Anti-periodic, Anti- diabetic, Prevent body aches, Kidney pain and Vomiting	(24, 25)
3.	Stem	Strengthen, Datum for cleaning, gums and teeth	(26, 27)
4.	Bark	Hair tonic, Carminative and Stomachic	(28)
5.	Fruits	Astringent	(11)
6.	Roots	Analgesic, Anti-helminthic, Cooling agent, Kidney pain, Blood disorders, Itching, Inflammation	(29, 30)

4. Phytochemical study

Alkaloids, flavonoids, polyphenols, and terpenoids have all been isolated from the Curry leaves, stem, bark, and roots, as well as from plant extractions (31). There is a lot of nearby composition in the plant leaves, including 63.2% moisture, 8.8% protein, 39.4% carbohydrate, 1.15 % total nitrogen, 6.15% fat, 18.92% total sugar, 14.6% starch, and 6.8% crude fibre (32, 33). According to reports, curry leaves are a significant source of a number of vitamins, including calcium, magnesium, sodium, and vitamin A (β-carotene), which has a level of 6.04 0.02 mg/100g, vitamin B3 (niacin), which has a level of 2.73 0.02 mg/100g, vitamin B1 (thiamin), which has a level of 0.89 0.01 mg/100g, and vitamin B3 (niacin Alkaloids, essential oils, carbazole, flavonoids, and terpenoids all play helpful functions all over the world (34). List of *Murraya koenigii*'s main chemical components, including plant parts are described in Table 4 and Figure 1 (35, 36).

The initial phytochemical screening of the extracts in ethanol, petroleum ether, chloroform, aqueous, and ethyl acetate was carried out. Several extracts contained alkaloids, carbohydrates, flavonoids, and sterol, which were all found to be present (37). To confirm the phyto-constituents in the curry tree extract, numerous experiments were carried out. When alkaloids were added to chloroform, petroleum ether, alcohol, ethyl acetate, and water extracts separately, Mayer's reagent confirmed the test for alkaloids, which showed the formation of cream- or white-colored precipitates (38). After adding a few drops of lead acetate (5%) solution to an alcoholic root extraction, the formation of a white precipitate allowed researchers to identify the presence of phenolic components. The presence of flavonoids was detected by dipping yellow filter paper

into the aqueous and alcoholic extract with ammonia (39). While the extract exhibited honey comb-like foaming after being shaken with sodium bicarbonate, saponins were thought to be present. The presence of free amino acids and proteins was determined using the Biuret's, Millon's, and Ninhydrin's tests (36, 37). While the hydro-alcoholic extract was being shaken, CHCl3, a few drops of (CH3CO)2O, and a few drops of concentrated H2SO4 were added from the tube's side. This resulted in the formation of a blue to brick-red colour that signifies the presence of triterpenes and sterol (33). The plant's bitterness, which is measured at 2.5 units/gm, can be used. The plant has hemolytic properties. The presence of carbohydrates and amino acids was checked in the extracts, both aqueous and alcoholic (39).

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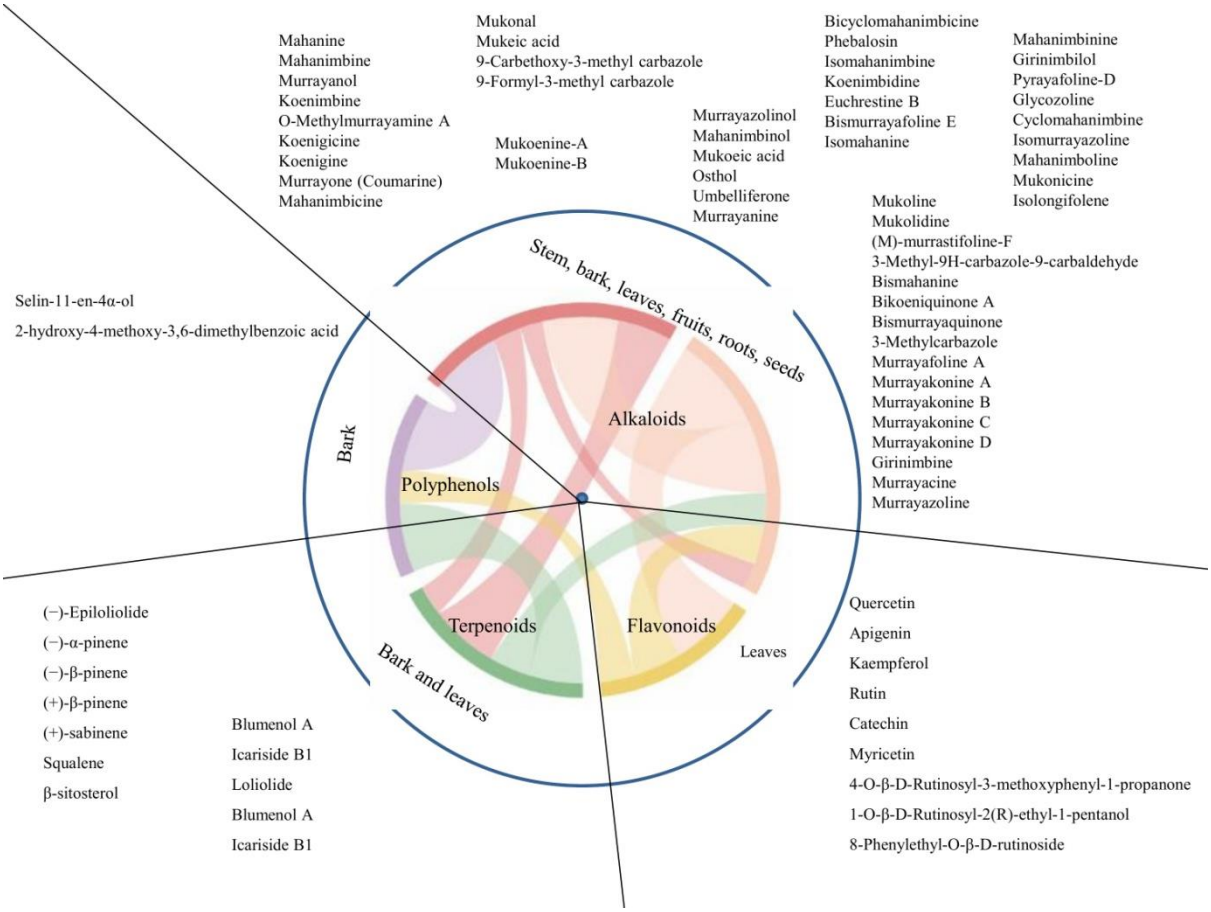

Figure 1. List of phytochemicals present in *Murraya koenigii* (16, 33, 40).

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Table 4. The major chemical constituents of *Murraya koenigii*.

Classification	Name of Components	Plant Part	References
Alkaloids	Mahanine	Stem, bark, leaves and seeds	(16, 33, 40)
	Mahanimbine	Stem, root, leaves and seeds	
	Murrayanol	Leaves, fruits and roots	
	Koenimbine		
	O-Methylmurrayamine A	Leaves	
	Koenigicine		
	Koenigine	Stem, bark and leaves	
	Murrayone (Coumarine)	Leaves	
	Mahanimbicine		
	Bicyclomahanimbicine		
	Phebalosin		
	Isomahanimbine	Leaves and roots	(11, 33, 40)
	Koenimbidine		
	Euchrestine B	Leaves	
	Bismurrayafoline E		
	Isomahanine	Leaves, fruits and seeds	
	Mahanimbinine	Leaves and seeds	
	Girinimbilol	Leaves	
	Pyrayafoline-D	Leaves, stem bark	
	Glycozoline	Leaves	
	Cyclomahanimbine		
	Isomurrayazoline		
	Mahanimboline		
	Mukonicine		
	Isolongifolene		
	Mukonal	Stems	
	Mukeic acid		
	9-Carbethoxy-3-methyl carbazole	Roots and stems	
	9-Formyl-3-methyl carbazole		
	Murrayazolinol	Stems bark	(36, 37, 41)
	Mahanimbinol		

	Mukoeic acid		
	Osthol		
	Umbelliferone		
	Murrayanine		
	Mukoenine-A	Roots, stem bark	
	Mukoenine-B		
	Mukoline	Roots	(40, 41)
	Mukolidine	Stem bark and roots	
	(M)-murrastifoline-F		
	3-Methyl-9H-carbazole-9-carbaldehyde	Roots	
	Bismahanine	Stem bark and roots	(36)
	Bikoeniquinone A		
	Bismurrayaquinone		
	3-Methylcarbazole	Roots	
	Murrayafoline A		(40-41)
	Murrayakonine A	Stem and leaves	
	Murrayakonine B		
	Murrayakonine C		
	Murrayakonine D		
	Girinimbine	Stem bark, roots and seeds	
	Murrayacine	Stem	
	Murrayazoline		
Flavonoids	Quercetin	Leaves	(42, 43)
	Apigenin		
	Kaempferol		
	Rutin		
	Catechin		
	Myricetin		
	4-O-β-D-Rutinosyl-3-methoxyphenyl-1-propanone		
	1-O-β-D-Rutinosyl-2(R)-ethyl-1-pentanol		
	8-Phenylethyl-O-β-D-rutinoside		
Terpenoids	Blumenol A		(43, 44, 45)
	Icariside B1		
	Loliolide		
	Blumenol A		
	Icariside B1		
	(−)-Epiloliolide		
	(−)-α-pinene		
	(−)-β-pinene		
	(+)-β-pinene		
	(+)-sabinene		
	Squalene	Bark and leaves	(43)
	β-sitosterol		(44-45)
Polyphenols	Selin-11-en-4α-ol		
	2-hydroxy-4-methoxy-3,6-dimethylbenzoic acid	Bark	

5. Folk/traditional use

Essential oils, fresh leaves, and dried leaf powder are frequently used to season other food preparations, seafood, soups, meat dishes, eggs, and curries. The soap industry and the cosmetic aromatherapy sector both employ essential oils (46). For maintaining healthy hair tenor and promoting hair development, curry leaves are utilised as an excellent hair tonic (47). Coconut oil is used to boil the leaves of this tree until a concentrated residue forms. The whole or parts of the plant are traditionally used as a treatment for nausea, vomiting, blood purification, depressive disorders, fungal infections, bodily aches, and diarrhoea as seen in Figure 2 (48). The indigenous people have employed barks and roots to treat dangerous animal bites. When consumed uncooked, the green leaves of *Murraya koenigii* assist alleviate morning sickness and diarrhoea. Boils are relieved by root juice and kidney pain is relieved by leaf paste, respectively (49). Along with lime juice, green curry leaves eaten raw aid in the treatment of diarrhoea and morning sickness (50). Boils and kidney pain are respectively relieved by root juice and leaf paste. The flavour of the fragrant leaves is distinctive. The dried curry leaf powder is combined with honey and betel nut juice in the Ayurvedic medical system as an anti-periodic (51, 52). Curry trees also contain iron, Vitamins A, B, B2, and C, and were used as a calcium supply for people who needed it. Traditional uses for this plant include antifungal, antidepressant, anti-diarrheal, anti-inflammatory, and blood purifying properties, either in part or whole (53, 54).

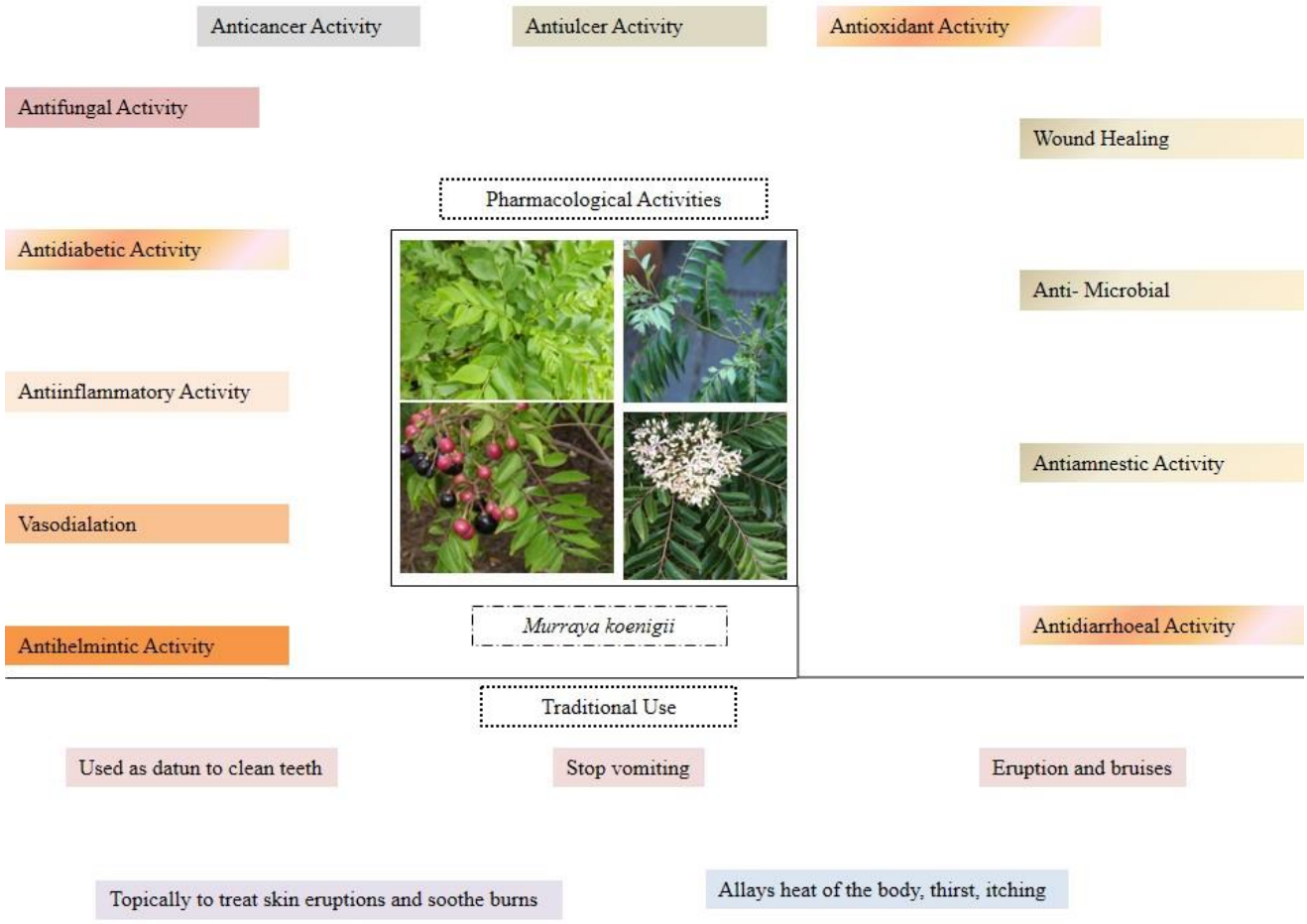

Figure 2. Pharmacological activity and traditional use of *Murraya koenigii* (59, 62).

6. Pharmacological activity

Researchers have discovered a number of pharmacological activities present in *Murraya koenigii*, as this plant contain several phytochemicals with varied compositions. Curry plant also shows Pharmacological

activities such as Neuro-protective activity through decreasing Glycemic levels, Anti-Nephrotoxicity activity against unilateral renal ischemia (55), it also exhibits decreased GI motility (Anti-Diarrheal Activity), anti-ulcer activity by working against lesion index, *Murraya koenigii* prevents tooth decay, stimulates digestive enzymes, lowers total cholesterol, acts as an anti-pyretic by reducing fever, acts as a memory enhancer, and promotes wound healing (56, 57). Curry tree exhibits insecticidal, phagocytic, anti-helmintic, hypercholesterolemic, anti-nociceptive, analgesic, and vasodilatory activities (see Table 5 and Figure 2) (58).

6.1 *In-vitro* Studies

Antioxidative activity

According to the literature, various solvents were used to study the antioxidative capabilities of the *Murraya koenigii* leaf extract. Natural anti-oxidants derived from plants have been touted as a viable therapy for the treatment and prevention of many illnesses, particularly cancer, cardiovascular disease, and other illnesses as well as neurological disorders (59). *Murraya koenigii* contains a number of naturally occurring bioactive substances that have outstanding antioxidant activities, including mahanine, mahanimbine, isolongifolene, koenimbine, girinimbine, isomahanine, koenoline, and O-methylmurrayamine (60). They were assessed based on their radical scavenging capacity against 1-1-diphenyl-2-picrylhydrazyl (DPPH) and the oil stability index (OSI) (61). In comparison to those of α-tocopherol, the OSI values of the methylene chloride (CH2Cl2) extract and the ethyl acetate (EtOAc) soluble portion of the 70% acetone extract were significantly prolonged. Three categories were used to group the 12 carbazoles (62). Based on the oil stability index (OSI) and their ability to scavenge radicals against 1, 1- diphenyl-2-picrylhydrazyl 19, the antioxidative capabilities of *Murraya koenigii* leaf extracts employing various solvents were assessed. Two carbazole alkaloids, mahanimbine and koenigine, were isolated from the leaves of *Murraya koenigii* and demonstrated antioxidant activity. Additionally, Koenigine demonstrated strong anti-radical effects (63).

Antimicrobial Activity

Several investigations have shown that the plant itself has a number of active compounds with antimicrobial properties, including Mahanimbine, Murrayanol, Mahanine, and Gurjunene (64). The stem bark of *Murraya koenigii* was used to isolate benzoisofuranone derivatives, three known steroids, and six known carbazole alkaloids. These substances are proven to be efficacious at concentrations between 3.13 and 100 g/ml. *In-vitro* antibacterial activity against Gram positive and Gram negative strains of bacteria was tested using methanolic extracts of 21 different plant species, according to a literature review. A study revealed that *Murraya koenigii* had the strongest antibacterial effect. Curry leaf plant greatly reduced Staphylococcus epidermidis (29, 65). Three carbazole alkaloids- mahanine, murrayanol, and mahanimbine were discovered in the acetone extract of Curry fresh leaves. Mahanimbine demonstrated antioxidant activity at 33.1 g/ml, whereas murrayanol had an IC50 of 109 g/mL against hPGHS-1 and an IC50 of 218 g/mL against hPGHS-2 in anti-inflammatory tests. These three carbazole alkaloids all had antibacterial and mosquito-killing properties as well as topoisomerase I and II inhibitory activities (66).

Anticancer activity

Extracts from various plant parts have been shown through methodical study and pharmacological examination to have antiviral, anti-inflammatory, antioxidant, antidiabetic, anti-diarrheal, anti-leishmanial, and anticancer activity (67). Among a number of different chemical components found in plant extracts, the main bioactive component of the carbazole alkaloid mahanine has been identified (16). The chemopreventive as well as the therapeutic potential of this plant and its active ingredients against a variety of malignancies are demonstrated through the presentation of research articles in this review (68). By doing an *in-vitro* cell

line study, several studies reveal MK's anticancer properties. The *in-vitro* anti-tumor promoting action of a pure chemical, girinimbine, which was isolated from the stem bark of *Murraya koenigii*, was demonstrated by measuring the percentage suppression of the induced early antigen EA of Epstein Barr virus EBV on the surface of Raji cells (69, 70). According to a study, a polyphenol-rich hydro-methanolic extract of MK leaves (CLE) reduced cell viability, growth kinetics, and arrested the S phase of the cell cycle in MCF-7 and MDA-MB-231 breast cancer cells, therefore inhibiting 26S proteasome proteolytic activity and inducing apoptosis. According to this study, MK leaves are a powerful source of proteasome inhibitors and may be helpful in the treatment of many malignancies (71). Despite the beneficial outcomes of the *in-vitro* and *in-vivo* research, very few pre-clinical trials have been carried out to investigate the anticancer effect of phytochemicals. Because cancer is a persistent disease, it is necessary to investigate how it affects people through clinical trials in order to introduce this product as an anticancer drug (72).

Antifungal Activity

Several investigations have reported *Murraya koenigii*'s antifungal activity by resisting the growth of gram positive and gram- negative bacteria. For instance, it has been claimed that the leaves' essential oil has antifungal properties (73). The presence of phytochemical components with complex molecular structures and a variety of action mechanisms, such as alkaloids, terpenoids, flavonoids, phenolics, tannins, and saponins, which are known for their antimicrobial properties, is what gives *Murraya koenigii* leaves their antifungal properties (74). Various studies back up the plant's historic use as an antifungal agent. Curry leaves' use in traditional medicine for the treatment of diarrhoea, dysentery, and skin eruptions may be explained by their *in-vitro* antifungal action (75).

The ethanolic extract of *Murraya koenigii* had noticeable impacts on the morphology of the hyphae, including an increase in branching potential that led to the growth of brief, slender hyphal branches with inflated terminals (76). The current study comes to the conclusion that these plants contain a variety of chemical components that could be useful in pharmacology. It can be utilised to raise society's health level because it contains a variety of substances that are necessary for excellent health. Both plants' methanolic extracts exhibited a modest amount of antibacterial activity against the examined microorganisms (77).

6.2 *In-vivo* studies

Antidiabetic Activity

Currently, the major goal of treating diabetes is to reduce hyperglycemia over time by using a combination of insulin, conventional therapy, and α-glucosidase inhibitors (78). However, the effectiveness of these chemicals is debatable due to unintended side effects, which increases the possibility for alternative treatments in the management of diabetes (79, 80). For this reason, it has been argued that plants represent a vast, yet largely untapped source of potentially effective antidiabetic medication. Statistically considerable hypoglycemia potential is present in *Murraya koenigii* in STZ-induced rats with diabetes (81). The *Murraya koenigii* extract appeared to be more efficient than the well-known drug antidiabetic drug glibenclamide. The petroleum ether extract of the dried plant was used to isolate mahanimbine, a chemical component of *Murraya koenigii*.

On streptrozotocin-induced wistar rats, the anti-diabetic action was tested using a pure substance at doses of 50 mg/kg and 100 mg/kg. Mahanimbine may lower blood sugar levels by potentiating the effects of insulin, either by boosting pancreatic insulin secretion from beta cells of the islets of Langerhans or by enhancing peripheral glucose uptake (47). When compared to acarbose, mahanimbine had a noticeable alpha amylase inhibitory effect (82). However, given that plant substances act more slowly than synthetic drugs and

that higher dosages may have a plateau effect, which would be harmful to the treatment of diabetes, long-term research is necessary (3, 81). It will need more research to extract and pinpoint the precise active ingredients that give the examined plant materials their antidiabetic properties (11, 82).

Antiulcer Activity

One of the most prevalent gastrointestinal diseases is the peptic ulcer. *Murraya koenigii*'s aqueous extract has anti-ulcer properties (83). The antiulcer properties of *Murraya koenigii*'s aqueous and ether extracts were investigated in albino rat models of stomach ulceration brought on by reserpine (4). Using hot aqueous leaf extract at dosages of 250 and 400 mg/kg, the anti-ulcer efficacy was seen. The extract prevented stomach lesions brought on by pylorus ligation and anti-inflammatory, non-steroidal medicines. In a pylorus ligation model, the extract decreased gastric volume, ulcerative lesions, free and total acidity but increased the pH of gastric juice (79). The findings revealed that the extract has strong anti-ulcer properties (47). Extracts appeared to be as protective as ranitidine in treating stomach ulcers. The anti-ulcer activity of a crude aqueous extract of leaves was assessed using rat models of acute gastric lesions brought on by ethanol, aspirin, cold restriction stress, and pylorus ligation. These findings support previous research suggesting that an aqueous extract of *Murraya koenigii* leaves can be an effective antiulcer medication (84).

Anti-Inflammatory Activity

The leaf extracts of *Murraya koenigii* have anti-diabetic properties in addition to having some effects that control immunology in relation to oxidative stress metabolism. Expression of the cytokines interleukin (IL)-2, 4, 10, and tumour necrosis factor alpha (TNF-alpha) demonstrated this immune-modulatory and anti-inflammatory action (85). Various studies revel that the anti-inflammatory and analgesic activity of methanol extract of dried *Murraya koenigii* Linn leaves given orally to healthy animals at doses of 100, 200, and 400 mg/kg body weight. Carrageenan-induced hind paw edoema in albino rats was used to test the extract's anti-inflammatory action. At various time points following injection of carrageenan (1% w/v), the mean increase in paw volume and inhibition in paw volume were determined plethysmometrically. The effectiveness of the extract as an analgesic was also examined in albino rats using the Eddy's hot plate method and the formalin-induced paw licking method. The carrageenan-induced paw edoema was significantly reduced (P 0.001) by the methanol extract, and analgesic effectiveness was demonstrated by an increase in reaction time using the eddy's hot plate method and a percentage increase in pain during the formalin test. Comparing the methanol extract to the standard and reference medicine, diclofenac sodium (10mg/kg), the anti-inflammatory and analgesic effects were dose-dependent. Statistics showed that these inhibitions were significant ($P < 0.05$). Thus, our research implies that curry plant may be useful in the treatment of diseases that are related to inflammatory pain (2).

Antihelmintic Activity

When compared to the common medication Piperazine, the *Murraya koenigii* leaves' ethanolic and aqueous extract demonstrated anti-helmintic action, various research data revels that it is thought that the polyphenolic component tannins, which are contained in the leaves, are what give them their antihelmintic properties. The methanolic extract has antihelmintic activity against Indian earthworm in a dose-dependent manner, such that it can paralyse the worm in 18 minutes and have a deadly effect in 45 minutes (86).

Wound Healing Activity

Mahanine, Mahanimbine, and Mahanimbicine are only a few of the phytochemicals found in *Murraya koenigii*'s leaves, stem, and bark's ethanol extract that have wound-healing properties (45).

Anti-amnestic activity

After being treated with *Murraya koenigii* leaves, rats using behavioural models of scopolamine, aging-induced forgetfulness, and diazepam were assessed for memory improvement (87). Several groups were given plants-leaf powder mixed with wheat flour by mouth, and their behaviour was assessed using elevated plus-maze and Hebb-Williams maze trials. The memory scores of both young and old rats showed a significant dose-dependent improvement, and the induction of scopolamine (0.4 mg/kg, i.p.) and diazepam (1 mg/kg, i.p.) in the treatment groups may have contributed to the significant reduction in forgetfulness (88).

Antidiarrhoeal activity

Three pure compounds of bioactive carbazole alkaloids kurryam, koenimbine, and koenine were isolated from the n-hexane extract of *Murraya koenigii* seeds under the guidance of a bioassay. Kurryam and koenimbine, two of the three substances, significantly inhibited rats' castor oil-induced diarrhoea and PGE2-induced enter pooling (89). Also, the substances significantly decreased Wister rats' gastro-intestinal motility in the test using charcoal meals (90).

Table 5. Pharmacological use of *Murraya koenigii*.

No.	Uses	Phytochemicals	Pharmacological action	Reference
1.	Anti-Diabetic	Koenimbidine, Murrayazolinine, Murrayacine	Decreases Oxidative Stress	(91)
2.	Anti-Trichomona	Girinimbine, Mahanimbilo	Doing Against Trichomonas Gallinae	(69, 92)
3.	For Oral Health	Essential Oil	Stimulating Salivation Process	
4.	Vasodilation	Mahanimbilol, Murrayazolinine	Work as negative Chronotropic Effect	
5.	Anti-Oxidant	Mahanimbine, Koenigine	Reduction in Hepatic Malondialdehyde In the Kidney	
6.	Anti-Cancer Activity	Girinimbine, Mahanine, Mahanimbine, Murrayafoline	Proliferation Death of Cancer Cell Proteasome Inhibitor	(90)
7.	Bronchial Disorders	Girinimbine, Mahanine	Block 5-Lipooxygenase Activity	
8.	Effect in Dental Caries	Isomahanine, Mahanine and Murrayanol	Inhibit of Cavity Formation	(92)
9.	Anthelmintic Activity	Mahanine, Koenimbidine	Cause Paralysis	(69, 92)
10.	Effect on Wound Healing	Mahanine, Mahanimbine, Essential Oil, Mahanimbicine	Work Against Inflammatory Cells And reduce Collagen Deposition	(93)
11.	Anti-Amnesic	Koenimbidine, Mahanimbicine	Protect Against the Neurodegenerative Diseases	(11)
12.	Improves Eyesight	Essential Oil and Vitamin A	Eye Sight Improvement	(92)
13.	Radiation Protection Activity	Mahanine, Murrayafoline	Increases Glutathione, Includung Enzymes Levels and Decrease Chromosomal Damage	(83)
14.	Anti-Ulcer Activity	Mahanimbine And Essential Oil	Effect against Lesion Index, Area and Percentage of Lesion and On Ulcer	(6)

15.	Anti-Microbial Activity	Mahanimbine, Mahanine, Murrayanol	Inhibition of Topoisomerase I And Ii	(92)
16.	Anti-Diarrhoeal Activity	Kurryam, Koenine, Koenimbine	Prostaglandin E2-Induced enter pooling and reduction in gastrointestinal motility	(2)
17.	Chemo-protective Activity	Koenimbin	Reduce Chromosomal Damage	(94)
18.	Immunomodulatory Activity	Mahanimbine, Mahanine	Remove Carbon Partical From Blood	(95)
19.	Haema-tological Activity	Koenimbidine, Mahanimbicine	Not any Adverse Effect Against Food Efficiency Ratio	(92)
20.	Antipyretic Activity	Murrayacine, Murrayazolinine	Murrayacine, Murrayazolinine	(96)
21.	Nephro-protective Activity	Koenimbidine	Work against unilateral renal Ischemia	(1,96)
22.	Cardio-Protective Activity	Girinimbine, Girinimbiol	Cadmium-Induced Oxidation Is Reduces	
23.	Anti-Cytotoxicity Activity	Girinimbine, Koenoline, Mahanine and Pyrafoline-D	Exhibiting Cell Death Resulted As The Mortality Of The Cell	
24.	Inotropic Activity	Girinimbiol	Positive Inotropic Effect	(97)
25.	Hepatoprotective Activity	Mahanimbine, Isomahanimbine, Girinimbine, Mahanine, Murrayazolidine, Murrayazoline	Oxidative Stress Inducer	(98)
26.	Anti-Lipase Activity	Mahanimbin, Koenimbin and Koenigicine	Reduced Total Cholesterol (Tc) And Triglyceride (Tg) Levels	(92)
27.	Anti-Alzheimer's Activity	Isomahanimbine, Murrayazolidine	Improves the Values of Protective Antioxidants	
28.	Anti-Analgesic Activity	Mahanine, Mahanimbine, Girinimbine, Isomahanimbine	Anti-Nociceptive Effects	
29.	Effect Digestive System	Mahanine, Murrayafoline	Stimulates Digestive Enzymes	(93)
30.	Neuro-Protective Activity	Koenimbin, Clausazoline-K, Koenigicine	Decreasing Glycemic Levels	(92)
31.	Anti-Inflammatory Activity	Mahanine, Mahanimbine, Girinimbine, Isomahanimbine	Cox-Inhibitory Activity	

7. Conclusion

All around the world, medicinal herbs are less expensive and freely accessible. As a result, we must increase the commercial usage of medicinal plants as a reliable supply of medication. *Murraya koenigii* is a readily available, multipurpose plant that has the ability to treat a wide range of common ailments as well as

challenges we face every day. The therapeutic applications, phytochemistry, and pharmacological characteristics of *Murraya koenigii* are outlined in the current review. Several bioactive substances, such as alkaloids, polyphenols, terpenoids, and flavonoids, are found in *Murraya koenigii*. The pharmacological effects of *Murraya koenigii* and its derivatives, such as anticarcinogenic, proapoptotic, antiangiogenic, antimetastatic, immunomodulatory, and antioxidant capabilities, appear to be quite significant. The diverse roles that *Murraya koenigii* and its derivatives play in a variety of cell signalling pathways at various levels in different illnesses are the basis for the molecular mechanisms behind these activities. Oxidative stress, neurotoxicity, neuroinflammation, neuronal loss, and cognitive dysfunctions are all reduced by *Murraya koenigii* and its derivatives. However, like other polyphenols, *Murraya koenigii*'s actions are somewhat constrained by its bioavailability, and in such circumstances, efficiency improvement should be carried out. Therefore, further experimental research on improving bioavailability and efficiency in clinical studies has to be included in future studies.

Supplementary Material

Supplemental data contains two figures showing the compounds' structures identified in *Murraya koenigii*. Supplemental Figure 1 (https://etflin.com/file/document/20231106143132187560376 7.png); Supplemental Figure 2 (https://etflin.com/file/document/20231106143132321503236.png).

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Data Availability

All data related to this review are available within the paper and its Supplementary Information.

Conflict of Interest

The authors declare no conflict of interest.

Authors contribution

Conceptualization : Sattwik Das; Shouvik Kumar Nandy
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Supervision : Sattwik Das
Administration : Sattwik Das
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