

Ethnobotany, Phytochemical, Pharmacological Potentials of *Murraya koenigii*, and Its Health Benefits – A Review

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Authors' contributions

This work was carried out in collaboration among all the authors. Authors RC and PG designed and conceptualized the study. Author RC wrote the first draft of this manuscript. Author LV managed the literature searches. All authors read and approved the final draft of this manuscript.

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Review Article

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ABSTRACT

Murraya koenigii, also widely known as curry leaves and curry patta, is a noticeably significant plant recognized all around the world for its tremendous therapeutic, medicinal worth and characteristic aromatic properties. It is one of the major export commodities originated from east and southern part of India bringing good foreign revenue. This review article is designed to assess and compile all the currently available literature on ethnobotanical aspects and phytochemical, pharmacological potentials of *M. koenigii*. Morphologically, it is a semi deciduous small shrub or aromatic shrub having slender but strong woody stem with branches covered with grey bark. The whole plant of *M. koenigii* viz., as stem, leaf, fruits, root and seeds have been accounted to have anti-oxidant, anti-fungal, anti-candidal, anti-bacterial, anti-hypersensitive and various biological properties. It is also additionally used in hormonal therapy in traditional medicines as a dysenteric, blood purifier, diuretic, febrifuge, hair tonic, anti-inflammatory, analgesic, antipyretic and anti-diarrheal. *M. koenigii* oil is said to have massive impact in the pharmaceuticals and in aromatherapy enterprises as a powerful ingredient. Many researchers have worked on all parts of *M. koenigii*, from roots, stem, leaves up its bark. This review is an attempt to summarize all the diverse literature available so as to compile a reliable review article on *M. koenigii* providing detailed information on therapeutic potential, health benefits and pharmacological applications of the plant.

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1. INTRODUCTION

Curry plant (*Murraya koenigii*) is dispersed and naturally cultivated pan India, from Western Ghats to Garhwal, Sikkim, Assam, Cochin and Bengal. The plant is chiefly propagated through seeds preferably underneath partial shade for better germination. It originates from east and southern part of India, Pakistan, Sri Lanka, China but widely cultivated in East Asia and Australia. It is also available in various other parts of Asia as well as in moist tropical forests of 500-1600 m height in Guangdong, Laos, Bhutan, Nepal, Sri Lanka, Pakistan, Vietnam and Thailand. Despite not being observed outside the Indian sphere, curry leaves have also reached Réunion island, Malaysia and South African conjunction with immigration of South Indians [1].

M. koenigii and *M. paniculata* are the two species of flora found in the Indian sphere out of 14 international species of the genus [2]. Amongst the two, *M. koenigii* is vastly popular for its medicinal, flavoring and culinary potential. This sub-tropical plant is native of moist forests and even wastelands sometimes in India, Andaman Islands, Bangladesh and Sri Lanka except Himalayan region. According to Tamil and Kannada literature, *Murraya* leaves have been used in food items from around 1st century AD to 4th century AD. Origins of the word 'curry' comes up from the Tamil language with the word 'kari' meaning 'spiced sauce' [3].

1.1 Botanical Description

Murraya koenigii is a sub-tropical semi deciduous aromatic shrub or small tree up to 6 meters in height with strong but willowy wooden stem and branches with grey bark and many brown- green coloured spots. The stem is aromatic and is more or less deciduous shrub or small tree having up to 6 meters height and about 15 to 40 cm diameter. The main stem is dark green to brownish in colour. The white wood that lies underneath the bark can be exposed by longitudinally peeling off. Leaflets are bipinnately compound with reticulate venation. Inflorescence bears 60-90 flowers. Funnel-shaped sweetly scented white coloured flowers are borne on the shrub with complete, regular, bisexual, ebracteate, pentamerous, actinomorphic and hypogynous in nature flowers [4]. A fully opened flower can have an average diameter upto 1.12 cm. Calyx is 5 lobed, green persistent and

inferior; corolla is lanceolate, polypetalous with 5 white coloured inferior petals upto 5 mm in length; inferior androecium, polyandrous, with 10 stamens arranged into two bunch; smaller stamens are about 4 mm long whereas the longer ones are about 5-6 mm in length; gynoecium is about 5-6 mm long; stigma is sticky and bright; style is short; superior ovary. Fruits are glandular, occurring in small ovoid or sub-globose, close clusters with thin pericarp. Seeds are bi-seeded having spinach green color [1]. The individual seed is about 11 mm in length and 8 mm in diameter and may weigh up to 445 mg.

1.2 Phenology

Flowering occurs all the way through the spring, summer as well as monsoon season with the deciduous phase for leaves in the winter months during its resting period. Well-drained soil and fertilizers are needed in summers [5]. Leaf harvesting begins after 15 months from planting and is repeated after every 2 months or 3 months. The fruiting season continues from June end till the August end, with July as its peak fruiting season.

1.3 Reproduction

Reproduction in *Murraya* chiefly comes through seed dispersal germinating freely under partial shade. Propagation by stem cuttings and air layering is also possible. Curry leaf is a hardy crop. It can be tolerating higher temperature but when the temperature falls down below 16°C the vegetative buds become dominant arresting new growth of the plant [6].

Table 1. Taxonomic Classification [8]

Kingdom	Plantae
Subkingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Order	Sapindales
Family	Rutaceae
Genus	<i>Murraya</i>

1.4 Ecology and Cultivation

The plant is sub-tropical and can be best grown under full sunlight but can bear semi shade in summers and protected warm area in winters.

Maintain humid environment in hot and dry summer area [7]. They are frost sensitive in nature. Well drained soil, enriched with lots of organic material is best suited for its growth. Heavy clay with poor drainage is not suitable for cultivation of curry plant.

1.4.1 Vernacular names in Indian languages

- Bengali: Barsunga
- Gujarati: Mitholimdo
- Hindi: Meetha neem, Karipatta, Bursunga, Kathnim
- Kannada: Karibevu
- Malayalam: Kareapela, Kariveppilei
- Marathi: Karipat, Karhipatta, Karhinimb, Jhirang
- Oriya: Bansago

1.4.2 Names in other languages

- Burmese: Pindosine
- Danish: Karry bald
- Dutch: Kerrie bladeren
- English: Curry leaves
- French: Feuilles de cury
- German: Curry blatter;
- Indonesian: Daunkari
- Italian: Fogli de Cari
- Spanish: Hoja

2. ANATOMICAL CHARACTERISTICS

Unicellular trichomes with obliterated lumen area characteristic present in the basal region of *M. koenigii* leaves found chiefly on midrib. Petiole bears parenchymatous pith and pericyclic fibers of long length (upto 2000µm in length) form midrib. Alongside, large cruciferous anomocytic stomata and calcium oxalate crystals are present. Powdered leaves can fluorescence brownish black coloration. The root bears tetrarch to pentarch stele, presence of concentric grains in parenchyma and absence of phelloderm fibres. The fruits are edible, yielding 0.76% of a yellow volatile oil used as a fixative [9]. Transverse section shows a dorso-ventral structure. Cells of the epidermis can be cubical or elongated in shape. The upper layer of epidermal cells appears straight walled and composed of polyhedral palisade parenchymatous cells. This is followed by spongy parenchyma constituted of irregularly arranged isodiametric or rectangular cells; presence of prismatic calcium oxalate crystals; large and circular secretory canals. Xylem and phloem are present bellow midrib in a radiating

arc fashion followed by pericyclic fibres. Upto 1 to 3 layers of collenchyma cells are present in inner to the lower epidermis. Thin parenchymatous polygonal cells compose the ground tissue of the stem section [10].

3. PHYTOCHEMISTRY AND COMPOSITION

3.1 Leaves

The curry leaves have a diverse chemical composition. Researchers have reported about the presence of great content of secondary metabolites like flavonoids [11], alkaloids, antioxidants, sterols, resin and crystalline glycosides in plant extracts in solvents like ethanol, ethyl acetate, water, chloroform and petroleum ether. The leaves are good source of proteins, carbohydrates, minerals, vitamin C, vitamin B complex, carotene, fibres, nicotinic acid, oxalic acid, carbazole, and koenigin [12].

The leaves are widely used in cooking in Indian households. It is reported that chemical substances like O- phellandrene, P- elemene, P- caryophyllene and P- gurjunene are responsible for its aromaticity [13]. The presence of aromatic compounds like α - pinene, β - pinene, β - caryophyllene and β - phellandrene can potentially control the food spoilage unaided or in a combination. Major phytoconstituents consists of koenidine, koenimbine, koenigine, koenine, coumarine, girinimb, phebalosin, mahanimbicine, bicyclomahanimbicine, and isomahanimbine found in parts of the plant like roots, leaves, and bark [14].

Triterpenoid alkaloids viz., tetrahydromahanimbine and cyclomahanimbine are also present in leaves. It possesses a reserve of numerous carbazole alkaloids like girinimbine, koenioline, xynthyletin, murrayacine, murrayazoline and murrayazolidine, the main components of bark. The fruit pulp is composed of mostly total soluble sugars and lower levels of ascorbic acid, tannic acid and minerals like phosphorous, iron, calcium, potassium, and magnesium. Seeds have been reported to contain isobyanangelicol, xanthotoxin and furocoumarines [14,15]. The essential oil extracted from fresh leaves present a great calcium and vitamin A source. It contains caryophyllene, dipentene, di- α -phellandrene, D- α -pinene, D- α -terpinol and D-sabinene [15].

Mature leaves contain total sugars (18.92 %), total nitrogen (1.15 %), starch content (14.6 %),

fat content (6.15 %), moisture content (63.2 %), crude fiber (6.8 %), acid insoluble ash (1.35%), ash content (13.06 %), cold water extractive (27.33%), alcohol soluble extractive (1.82%), and highest in hot water-soluble extractive (33.45%). The proximate analysis showed high content of carbohydrate, proteins, fiber and fat [16]. The presence of vitamins like A, B1, B2, B3, C and E and minerals showed that these leaves can be consumed to as a dietary supplement in fresh or dry powdered form [17]. A wide variety of volatile oil, carotenoids, and carbazole alkaloids can be extracted and isolated from the leaf constituents [17].

Amongst all the phytoconstituents, leaves are known to contain chiefly six alkaloids-koenimbine, bispyrafoline, bismahanine, isomahanine, O- methyl murrayamine and O- methyl mahanine. Glycozoline, 1-formyl -3 methoxy- 6-methyl carbazole is isolated from dried *Murraya* leaves as well as 6, 7- dimethoxy-1- hydroxy- 3-methyl carbazole [18]. Acetone leaf extracts were said to contain mahanine, koenidine, koenine and koenigine and petroleum ether leaf extract specifically isolated isomahanimbicine. Bismurrayafoline E, bicyclomahanimbicine, cyclomahanimbine, Euchrestine B, mahanine, mahanimbine, mahanimbicine, mahanimbidine and mukonicine are a few example of carbazole alkaloids extracted and derived from dried *Murraya* leaves [17]. 8, 8"- biskoenigine is a new binary carbazole alkaloid along with its monomer koenigine were identified and isolated from leaves [19].

Koenimbine, Koenine and Koenigine, extracted from the leaves, possess anti- diarrheal, antioxidant and radical-scavenging properties. Hepatoprotective nature is inherent in compounds like murrayazoline, murrayazolidine, tocopherol and isomahanimbine [20]. All leaf extracts like mahanine, E, euchrestine, bismurrayafoline, bismahanine, isomahanine, bispyrafoline, O-methyl murrayamine A, lutein, O- methyl mahanine, carotene and tocopherol also show antioxidant properties [5,21].

3.2 Stem

From alcohol extract of stem bark has isolated koenigine- quinone A and koenigine quinone B, structures were established as 7- methoxy- 3 methyl carbazole- 1,4- quinone and 6, 7- dimethoxy-3-methyl carbazole-1, 4- quinone respectively. 9- carbethoxy-3-methyl carbazole

and 9- formyl -3- methyl carbazole were identified [22]. 2- methoxy carbazole -3- carboxylate and 1- hydroxy -3- methyl carbazole were isolated from stem bark. Mukonal, a probable biogenetic intermediate of pyrano carbazole alkaloid along with Murrayazolinol (a minor carbazole alkaloid), mahanimbine, murrayazolidine, murrayacinine, mukonidine, murrayazoline, murrayanine, girinimbine and mahanimbine, girinimbine and mahanimbilol (possible biogenetic precursors of girinimbine and mahanimbine) has also been identified and isolated from stem bark [21,23].

3.3 Roots

Root and root bark extracts were prepared in benzene. Mukoline, girinimbine, marmesin- 1"- O-rutinoside, mukolidine, murrayanol, murrayagetin were isolated and extracted chiefly from the root extract amongst others. Three monomeric, five binary carbazole alkaloids and Koenoline (1- methoxy-3- hydroxy methyl carbazole) were also derived from the root and stem bark in *Murraya spp.* [24].

3.4 Seeds

In the chromatographic studies of petroleum ether extract of seeds, koenimbine, girinimbine, mahanimbine, mahanine, isomahanine [25] and 2- methoxy-3- methyl carbazole. Structural confirmation of bioactive carbazole alkaloids like koenimbine, koenine, kurryam were obtained by 2D NMR spectra [26].

3.5 Fruits

All the above mentioned carbazole alkaloids have been reported in the petroleum extract of fruit pulp. Koenimbine, girinimbine, mahanimbine, mahanine, isomahanine, murrayazolidine and murrayanol are a few namely [27].

3.6 Essential Oil

Steam distillation is best suited for the oil extraction from tender leaflets. Though hydro-distillation, solvent extraction and fluid carbon dioxide extraction methods have also been reported. It was observed that the volatile oil composition is greatly affected by the phenotypic, topographic, agroclimatic and genetic variability of the germplasm lines. On further GC-MS analysis of plants grown topographically in colder places; the essential oil from fresh leaves is

mostly formed of monoterpenoids and its oxygenated derivatives. It was reported that essential oil in the fresh leaves of *M. koenigii* chiefly contains apinene, present in 51.7% [25]. Other constituents include sabinene (10.5%), β -pinene (9.8%), β -caryophyllene (5.5%), limonene (5.4%), bornyl acetate (1.8%), terpinen-4-ol (1.3%), α -humulene (1.2%) and g-terpinene (1.2%) in essential oils from leaves [28]. GC-MS analysis of essential oil from flowers reported the maximum presence of 43.9 % sesquiterpenoids followed by 34.4% monoterpenoids. The major oil constituents are β -caryophyllene (35.8%), α -caryophyllene (9.17%), selinene (8.88), cardinene (8.43%), β thujene (4.12%), trans ocimene (3.12%), β -phellendrene (2.57%), gujunene (1.46%), linalool (0.27%), α -pinene (0.26%), β -elemene (0.18%). Hydrodistillation of fruits resulted in 0.13% volatile oil. Caryophyllene oxide (10.3%), β -caryophyllene (8.5%), tridecanoic acid (8.2%), terpinen-4-ol (8.0%), dehydroaromadendrene (8.0%) α -cadinol (7.3%), and (Z, E)-farnesol (5.7%) were a few major constituents out of 73 analysed in GC-MS studies of steam distillate oil [28,29].

3.7 Traditional Uses

- Freshly harvested curry leaves and its dried powder blends are usually used as seasoning for flavoring of soups, preparations of curries, butter milk preparations, eggs dishes, fish soups, chutneys and various other culinary dishes [30].
- Hot coconut oil mixed with curry leaves is a brilliant hair tonic stimulating hair health, growth, retention of natural tones, lesser hair-fall and dandruff.
- Application of fresh curry leaf paste mixed with fenugreek powder has been reported to lengthen hair and give them a natural shine.
- Since ancient times, it has been used completely or in parts due to its anti-emetics, anti-fungal, anti-diarrheal, anti-inflammatory, anti-dysenteric, blood purifier, analgesic tonic, stimulant, stomachic, febrifuge and carminative properties.
- The leaves are reportedly very efficient in control of diabetes mellitus.
- External application of the paste formed of crushed fresh leaves has been reported to be effectual in treating injuries, boils, bruises, skin eruptions. It also can be used in various special concoctions alongside

other herbs to treat snake poison and other animal bites [31].

- It is known to cure piles, reduce body heat, thirst, inflammation and body itching. Even leukoderma and blood disorders can be controlled.
- Pain associated with kidney disorders has been alleviated by the root powder of *M. koenigii*. Fruits are known to possess nutritional properties.
- The essential oil is also utilized by soap and cosmetic aromatherapy industry [32].

3.8 Pharmacological Profile

The extracts of *Murraya* leaves are said to be therapeutic in nature. This ability of the plant is attributed to the diverse chemical composition including carbazole alkaloids and ascorbic acid, oxalic acid, nicotinic acid, α -tocopherol, flavanoids, antioxidants, terpenoids and minerals. It can also act as free radical quenchers as a result of its chemical properties [33].

3.9 Antimicrobial Activity

Antimicrobial agents are often used against infection causing pathogenic microbes as they pose as a great threat to the growth and reproductive cycles of the crops. The repeated use of antibiotics though has led to formation of antimicrobial resistance [34]. Therefore, herbal drugs have emerged in the recent times to be used in place of synthetic drugs as they pose no damage to the natural cycle of crop plant with minimal side effects. Natural antimicrobial compounds from the leaf extracts have been generally reported to be comparatively safe than synthetic ones as an effective oral dose [31]. No signs of toxicity were detected when tested on rodents [31].

Alkaloids, flavonoids and phenolic compounds present in the extract of leaves are reported to have growth inhibiting property against microbes predominantly by leakage of cytoplasmic constituents, damage to the plasma membrane, inhibiting synthesis of nucleic acid, cell wall disruption and disruption of energy metabolism processes [35]. Furthermore, plants reportedly produce numerous bioactive compounds which are defensive and toxic in nature [36]. These are the phytochemicals and bioactive compounds which in various combinations and concoctions have been used in traditional herbal medicinal sciences [37].

3.10 Antibacterial Activity

Mahanimbine, murrayanol and mahanine are the three chief alkaloids present in the pure essential oil of curry leaves which are responsible for the antibacterial effect against bacteria like *Staphylococcus aureus*, *Bacillus subtilis*, and *Pasteurella multocida*. The alcoholic and acetone leaf extract are also reported to show mosquitocidal, antibacterial and antimicrobial activity [38].

3.11 Anticancer Activities

Studies on plant extracts of *M. koenigii* have recorded significant anticancer properties and its cytotoxic effects [39]. Caryophyllene, Sabinene and other monoterpene hydrocarbons present predominantly in extracts and essential oils of *Murraya spp.* were said to have various cytotoxic effects against tumour cell lines [40].

3.12 Anti-oxidative Property

M. koenigii leaf extracts of contain various carbazole alkaloids viz., mahanimbine and koenigine which shows radical-scavenging properties against 1-1-diphenyl-2-picrylhydrazyl i.e., DPPH radical and the oil stability index (OSI). *Murraya* leaf extracts resulted in preparation of a novel nitric oxide NO radical scavenger causing a regulatory effect on the nitric oxide (NO) and its derivatives levels further curing various pathological conditions that may have arisen due to its high levels [41].

Amma et al. 2019 [42] demonstrated the role of *Murraya* leaf extract against Hela cell line causing cervical cancer. The results showed that the all the three viz., hexane, ethyl acetate and methanol extracts possess potent and strong cytotoxic activity with $Cd_{50} \leq 1 \mu\text{g/ml}$.

3.13 Antifungal Activity

Pure oil extracted from the leaves of [43] *M. koenigii* were administered at a dilution of 1:500. It exhibited antifungal activities against *Microsporum gypseum*, *Aspergillus niger*, *Candida albicans* and *C. tropicalis*. In an experiment conducted by Arya et al. (2017) [44] on *Rhizoctonia solani* and *Colletotrichum falcatum*, leaf ethanolic extract demonstrated fungi toxicity against them. The aqueous and ethanolic extract failed to show any kind of antifungal or anti-candidal effects [45]. No antifungal development was observed against

phytopathogenic fungi in the distilled water extract. Benzene solvent extract was effective against *Alternaria solani*. While, Acetone extract of *M. koenigii* proved to be highly effective against *Aspergillus niger* [44].

3.14 Antihelmintic Effects

The leaves of *M. koenigii* possess great anti-helmintic properties comparable to that of the standard prescribed drug Piperazine. The ethanolic and aqueous extract exhibit anti-helmintic effects against Indian earthworm (*Pheretima posthuma*). It is believed that polyphenolic compounds such as tannins are responsible for the anti-helmintic effects. It is reported that tannins work by following uncoupling oxidative phosphorylation and further disrupting the energy generation or by free protein and glycoprotein binding to the host's gastrointestinal tract on parasite's cuticle leading fatal for the parasite [46]. Paralysis of Indian earthworm is caused by addition of methanolic extract of leaves at a time period of 18 minutes and lethal effect at a time period of 45 minutes [47].

3.15 Mosquitocidal Activity

Ajay et al. [48] in his study of the pharmacological effects of petroleum ether extracts and acetone solvent extracts of the *M. koenigii* leaves observed its larvicidal and mosquitocidal activity at a concentration ranging from 250ppm to 900ppm.

4. HEALTH BENEFITS OF PLANT

4.1 Capability of Enhancing Memory

M. koenigii leaves extract has a diverse range of total alkaloids present in it which further increase the activity of protective antioxidants like catalase, glutathione reductase, glutathione peroxidase, and superoxide dismutase in fibroblasts and human erythrocytes. All activities of antioxidants and alkaloids lead to lowering of anticholinesterase, lipid peroxidation and nitric oxide levels and increase in acetylcholine levels. Thus, playing an important role in protection against Alzheimer's and other neurodegenerative diseases [49] and making the cognitive skills such as memory better in mice, which may perhaps help in the cases of dementia [50].

4.2 Anti-Hypertensive Activity

M. koenigii along with succinic anhydride are among a few herbal products which contain the

angiotensin converting enzyme inhibitor [51]. This enzyme inhibitor leads to its activity as an anti-hypertensive food. Ethanolic extract of *M. koenigii* leaves are also said to increase the calcium (Ca^{2+}) availability in isolated heart in frogs from extracellular sites, also known as a positive type of inotropic effect [52]. The supplementation of 10-gram curry powder has been given to rats under in vitro conditions, the results were found to improve in the blood pressure levels, systolic and diastolic levels. This novel utilization suggests that curry leaf powder have modulating role in treatment of hypertension and improving healthy lifestyle of individuals [53].

4.3 Anti-obese Activity

Tembhurne and Sakarkar [54] researched extensively on *M. koenigii* leaf extracts and pure oil. It was found that the ethanolic extract when administered orally for a month in male rats lead to efficient lowering of body weight, cholesterol levels and triglycerides. Administration of ethanolic extract leads to lowering in the levels of low-density lipoproteins and increase of high-density lipoproteins. Thus, effectively reducing body weight and balancing of blood sugar levels. Aqueous leaf extract reportedly is very efficient in preventing unnatural fattening of various body areas and also lowers the excess body fat.

4.4 Hypoglycemic Effects

Leaf extracts of this plant are potentially reported to have eminent medicinal effect on the Diabetes Mellitus. It is reported that the leaves extract possesses various hypoglycemic agents which leads to a rather significant decline in the glucose level as was seen in diabetic Sprague Dawley rats under in-vitro conditions [55], increasing the pancreatic secretion of insulin from either bound cells or β -cells. Flavonoids present in the leaves extract potentially lead to lowering of the blood sugar levels in mice.

Glycemic index (GI) is the potential of a carbohydrate containing food to increase blood sugar level as compared to pure glucose. An effective method of controlling type II Diabetes Mellitus in individuals is by lowering the GI. Use of *Murraya* as a treatment for diabetes is clearly mentioned in Ayurveda. Experimentally it has been found that the dietary constituents of *M. koenigii* have a beneficial effect on carbohydrate metabolism, thus help in controlling hyperglycemia.[46] *Murraya* has known to

posses significant hypoglycemic action as its intake leads to increase in the activity of glycogen synthetase and decrease in the activity of glycogen phosphorylase and gluconeogenic enzymes [31-32].

In various studies conducted on streptozotocin induced male rats and diabetic rats a considerable lowering of cholesterol, triglycerides, and blood glucose levels alongside decrease in low density lipoprotein and increase in the levels of high-density lipoprotein [56]. The alcoholic extract of *M. koenigii* shows a significant reduction in the levels of cholesterol, triglyceride and blood glucose level [57]. Mahanimbine has been reported to be chief alkaloid responsible for antihyperglycemic, hypoglycemic and hypolipidemic effect.

4.5 Analgesic Activity

Various studies have been reported on the herbal pain-relieving medicines pertaining to its high demand due to minimal side-effects. Oral intake of its extract has been used since use of traditional folk medicines for pain relief [37]. Analgesic properties of bark extract of *Murraya* has been scientifically proved due to various studies conducted and observed [58]. The methanolic extract showed anti-inflammatory and analgesic effect in albino rats and other animals in dose dependent manner when compared with diclofenac sodium (a standard drug). The study was carried using carrageenan induced paw edema for anti-inflammatory tests while eddy hot plate method and formalin induced paw licking was used for analgesic effect [59].

4.6 Use in Cosmeceuticals

Cosmetics are made on cream bases which contain hyaluronidase inhibitors which are added for its moisturizing, anti-aging, skin-lightening and antioxidant property. Herbal extracts such as *M. koenigii* stem extract have been reported for maintaining natural skin pigmentation, sun protection factors, erythema, improving rough skin, and skin-lightening effect [48]. Curry leaf oil based cream is known to possess sun protection factor and it can be used as an additive in other cream based formulations to enhance sun protection factor in them.

5. CONCLUSION

M. koenigii is a multipotential medicinal plant, laced with biologically active compounds which

are responsible for numerous medical properties from every plant part and its time withstanding relevance. The leaves are a rich source of carotene, proteins, fibres, minerals, vitamin A, vitamin B complex, vitamin C. Review of its phytochemical profile documents the presence of monoterpene hydrocarbons, oxygenated monoterpenes and sesquiterpenes, which are responsible for its many pharmacological properties. It can be considered as a more appropriate choice of plant for a new medicinal breakthrough so with the intention formulating an important pharmacological remedy for the management and cure of ailments affecting humans with minimum side effects possible. The plant extracts contain many pharmacologically significant compounds like Caryophyllene, isomahanimbin, coumarine, koenidine, nicotinic acid, oxalic acid, carbazole, and koenigin. Linalool, elemol, carvone, nerone and other bioactive compounds present in the essential oils also makes it a promising contender for technical medical testing. Keeping in view the tremendous pharmacological activities and vast future potential, *M. koenigii* possibly will be utilized to assuage a number of varied diseases and medical conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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