



A Phytopharmacological Review on *Murraya koenigii*: An Important Medicinal Plant

Anjana Goel^{1*}, Ayushi Sharma², Sunanda Kulshrestha³

¹Associate Professor, Department of Department of Biotechnology, GLA University, Mathura, U.P, India.

²M.Sc. student, Department of Department of Biotechnology, GLA University, Mathura, U.P, India.

³Ph.D. student, Department of Department of Biotechnology, GLA University, Mathura, U.P, India.

*Corresponding author's E-mail: anjana.goel@gla.ac.in

Received: 10-03-2020; Revised: 22-05-2020; Accepted: 30-05-2020.

ABSTRACT

Murraya koenigii, commonly known as curry leaves, is a well-known spice and natural flavouring substance used in Indian households for preparing delicacies. It is of Indian origin, easily available throughout the year and has been a constituent of many Ayurvedic medicines since old age. It has been used traditionally by the folks to cure ailments besides adding taste in food. Studies of literature disclose many prominent pharmacological behaviours of the plant. Carbazole alkaloids which are copiously available in the roots, fruits, leave and bark has been accounted for their anticancerous, antinociceptive, antibacterial, antidiabetic and antioxidant activities. Beside them, the plant has an ample array of therapeutic activities. Pharmacology and phytochemistry of this plant requires an inclusive review of its prediction as a vital therapeutic manager for the managing of many diseases usually affecting humans. A recent review highlights the detailed report on clinical, pharmacological, photochemical and pre-clinical works carried out on *Murraya koenigii* and also notifies therapeutic aspects.

Keywords: Curry leaves, Traditional medicines, Phytochemistry, Pharmacological activity.

INTRODUCTION

Human desires in terms of food, clothing, shelter, flavours, fragrances and even medicines have been supplied by plants. Traditional medicine systems like Unani, Ayurveda and Chinese propagated the ideas of plants as medicine. Even some significant drugs used presently have been derived from plants. Saturation of conventional forms of drug discovery has led to a route where the science of ethnopharmacology and ethnobotany has been used as a guide to diverse sources and classes of compounds for the search of new molecules. It is the circumstance that the plant of the tropics by the asset of its diversity has a major function in being able to provide new leads.¹Hippocrates, the father of Medicine, almost 25-30 centuries ago, proclaimed "food is medicine and medicine is food" which can be justified with the example of the plant taken for review.²

Morphological description

Murraya koenigii is a small shrub of about 2-2.5m height and dark green and brown stem. The leaves are long and are seen to be in reticulate venation. Flowers found on the plants are white, funnel-shaped having sweet aromatic smell and round shaped fruits are 1.4-1.6cm length.

It is found throughout India and cultivated in parts of the country including Sikkim, Assam, Western ghats, etc. *Murraya koenigii* tree can be found in the moist forests, of 500-1600 meters" in height especially in S Hainan, Guangdong, S Yunnan, Sri Lanka, Nepal, Bhutan, Laos, Thailand, Vietnam. Upon with the South India immigrants, the curry leaves arrive in Malaysia, South Africa, and Reunion Island.^{3,4}

Taxonomic Classification

Kingdom - Plantae

Subkingdom - Tracheobionta

Superdivision - Spermatophyta

Division - Magnoliophyta

Class - Magnoliopsida

Subclass - Rosidae

Family - Rutaceae

Genus - *Murraya J. Koenig*

Species - *Murraya koenigii*

Traditional Uses

Essential oils, fresh leaves and powder of dried leaves are widely used for curries, flavouring fish, soups and meat dishes, eggs dishes, ready to use and seasoning other food preparations. The essential oils are also used by cosmetic aromatherapy and soap industry.⁴*Murraya koenigii* leaves are used as a first-rate hair tonic for keeping natural hair tenor and increasing hair growth. Leaves of this tree are cooked with coconut oil till a concentrated residue is formed. Parts or whole plant is traditionally used as a remedy for anti-emetic, blood purifier, depressant, anti-fungal, body aches, anti-inflammatory, anti-diarrhoea, in kidney pain and vomiting. Barks and roots have been used by the tribals to cure poisonous animals bite. Green leaves of *Murraya koenigii* when eaten raw helps in diarrhea and treating morning sickness along with lime juice. The paste of the leaves and juice of roots relieves boils and renal pain respectively.^{5,6,7}



Phytochemistry

The leaves of *Murraya koenigii* are found to have proteins, minerals, carotene, carbohydrate, fibre, vitamin C, vitamin A, nicotinic acid, calcium and oxalic acid. It also contains carbazole alkaloids, crystalline glycosides, koenigin, girinimbine, koenine, koenidine, iso-mahanimbine and koenimbine. Triterpenoid alkaloids, tetrahydromahanimbine, cyclomahanimbine are also present in the leaves. Murrayaline, murrayastine, pyrayafolinecarbazole alkaloids and lots of other chemicals have been isolated from *Murraya koenigii* leaves.⁵

The bark contains carbazole alkaloids like murrayazolidine, murrayacine, mahanimbine, koenioline, girinimbine and xynthletin. Whereas, fruits generally contain reducing sugar and small amount of acids and tannin besides containing Vitamin C.⁸

In vivo Pharmacological studies on *Murraya koenigii*

Anti-bacterial activity

The essential oils from *Murraya koenigii* leaves showed an anti-bacterial effect against *Corynebacterium pyogenes*, *Streptococcus aureus*, *Bacillus subtilis*, *Pasteurella multocida* and *Proteus vulgaris*. The oil was found active against the bacteria even at a dilution of 1:500. The acetone extract of the fresh curry leaves on fractionation gives bioactive compounds namely murrayanol, mahanine and mahanimbine.^{9, 10}

Another experiment reported by Harbi and group in 2016¹¹ tested the activity by ethanol extraction of leaves, against bacterial strains of *Staphylococcus*, *E.coli*, *Streptococcus proteus*, *Klebsiella pneumonia* and *Pseudomonas aeruginosa*. A clear zone of inhibition was found in case of all strains except *Klebsiella pneumonia* and *Pseudomonas aeruginosa*, this was comparable to antibiotics such as Amikacin and Gentamycin.¹¹

Anti-fungal activity

Anti-fungal activity against *Candida tropicalis*, *Candida albicans*, *Aspergillus fumigates*, *Aspergillus niger*, *Micro sporumgypseum* was observed by extracts of *Murraya koenigii* leaves. The alcoholic extract of the leaves confirmed fungitoxicity towards *Rhizoctonia solani* and *Colletotrichum falcatum*.¹²

Whereas methanolic and ethanolic extracts were found effective against mycelia growth in *Rhizoctonia solani* and *Fusarium oxysporum* with different efficiency.¹³

Anti-protozoal and Anti-trichomonal activity

Alcoholic extracts of curry leaves and complete plant (excluding roots) showed anti-protozoal action against *Entamoeba histolytica*. Carbazole alkaloids and their byproducts from *M. koenigii* leaves was found to exhibit anti-trichomonal activity in contradiction of Girinimbine and girinimbilol with IC₅₀ values of 1.07.¹⁴

Anti-cancer

Carbazole, girinimbine extracted from *Murraya koenigii* bark induces extensively programmed cell death in cells of HepG2. The results obtained from the study which was conducted by Bhattacharya *et al.* in 2010¹⁵ gave evidence that there was an involvement of death receptor arbitrated extrinsic pathway of apoptosis by mahanine. It produced anti-cancer activity in MOLT-3 cells but somehow did not produce in K562 cells. Furthermore, pyrayafoline, murrayoline and three carbazole alkaloids, mahanine exhibit major activity towards HL-60 cells.¹⁶ Mahanine as the major anti-cancerous bioactive molecule in *M.koenigii* has also been supported by Samanta in their review.¹⁷

Amna *et al.*, also demonstrated the potential of leaves and proved it to be cytotoxic against HeLa cancer cell lines.¹⁸ similar works have also been seen on intestine and colon cancer using animal models and treating them with the extraction of leaves.¹⁹

Immunomodulation

Methanolic extract isolated from *Murraya koenigii* leaves showed a significant increase in the phagocytic index which was achieved by the rapid removal of carbon particles from the bloodstream. An increase in antibody against ovalbumin and protection against cyclophosphamide induced myelosuppression was also observed. Thus, *Murraya koenigii* was found to hold properties of an immunomodulatory agent that stimulated humoral immunity and phagocytic function. However, these extracts were unable to stimulate cellular immunity.²⁰

Methanolic extract of *Murraya koenigii* has also been reported as a potent immunomodulator in azathioprine induced immunosuppressed animals. It increased the DTH response, phagocytic index, WBC count as well as % neutrophils count.²¹

Anti-oxidant

The green leafy vegetables are known to have a high amount of antioxidants. *Murraya koenigii* leaves were observed to have highest antioxidant potential when compared with four other leafy vegetables.²² According to the studies, aqueous extracts of *Murraya koenigii* leaves showed significant protection mechanism against cadmium induced damage of cardiac tissues of the rats.²³ Side effects of Piroxicam induced gastric damage in arthritic patients can be ameliorated by *Murraya koenigii* was proved by inducing gastric ulcers in rats and treating them by *Murraya koenigii*.²⁴ Benzene fraction of *Murraya koenigii* was reported to have antioxidant as well as antimutagenic activity in experimental animals.²⁵

Nephroprotective

A significant amount of reduction in creatinine levels (P<0.001) was observed when aqueous extracts of *Murraya koenigii* leaves were orally administered for 30



days in diabetic male rats, caused and serum urea. It was observed from histological studies that *the* administered extract produced tissue regeneration in kidneys.²⁶ Another experiment related to nephrotoxicity induced by cyclophosphamide also showed positive results after administration of aqueous and methanolic extract of leaves. This also validated the protective role of *Murraya koenigii* leaves for kidney.²⁷

Antipyretic activity

Ethanol extract of *Murraya koenigii* was reported for a significant antipyretic activity using yeast induce pyrexia in rat model.²⁸ Rageeb and group in their experiment including albino rats administered alcoholic extract of *Murraya koenigii* leaves for examination of antipyretic activity using yeast persuaded pyrexia model. The results were comparable to the commercial antipyretic, paracetamol.²⁹ Alcoholic extract of *Murraya koenigii* had significant antipyretic effect in PGE1 induced hyperpyrexia in rats.³⁰

Anthelmintic activity

Alcoholic and hot aqueous extracts from *Murraya koenigii* leaves were examined for their anthelmintic activity against *Pheretima posthuma*. The extracts revealed significant activity at a concentration of 100 mg/mL however; it was observed that ethanolic extract produced more anti-helmintic activity than petroleum ether extract.³¹ *M. koenigii* extract was evaluated against gastrointestinal nematodes *Haemon chuscontortus* of sheep. 100 % mortality of adult worms have been observed by crude methanolic extract after eight hours post-exposure.³²

Anti-ulcer activity

The anti-ulcer activity was observed using hot aqueous leaves extract at doses of 250 and 400 mg/kg. The extract produced inhibition of gastric lesion induced by anti-inflammatory, non-steroidal drugs and pylorus ligation-model. The extract reduced gastric volume, ulcerative lesion, free and total acidity but an elevation in the pH value of gastric juice in pylorus ligation model was seen. The results suggested that the extract holds significant anti-ulcer activity.^{33,34}

Anti-diarrheal activity

Murraya koenigii as a treatment of diarrhoea has already been in use since ages and in the literature of Ayurveda but experimentally it also showed significant results. The notable inhibitory activity has been observed against castor oil induced diarrhoea in rats. The Bioactive molecules namely koenimbine, carbazole and kurryam obtained from the fractionated n-hexane extract of seeds of *M. koenigii* showed activity against diarrhoea and gastrointestinal motility in charcoal meal test in rats.^{35,36,37}

Cardioprotective activity

Different types of studies have been undertaken to validate the work of *Murraya koenigii* as a cardioprotective agent. One such study includes the use of a hot aqueous

extract of leaves for treatment of rat cardiac muscles against cadmium induced oxidative stress. Infusion of rats with cadmium also produced variations in the activities of mitochondrial Krebs's cycle as fit as respiratory chain enzymes. All these went into better condition when the rats were pre-treated with a hot aqueous extract *Murraya koenigii*.³⁸ Another such experiment on cardiotoxicity by doxorubicin has also been done which may probably lead to irreversible congestive heart failure. A dose-dependent study was done which lead to the conclusion that the extract form leaves of *Murraya koenigii* are rich in flavonoids and phenols that could act as a free radical scavenger. The study showed positive results. Another idea by Pathak and Matule lead to study of lead induced cytotoxicity which had haemological, physiological and biochemical alteration on the body and could even propbaly lead to Ischemic Heart Disease. Differences were observed in thrombocyte indices such as PLT ($p < 0.05$) and P-LCR and the role of anti-oxidants present in leaves as chelating agent for lead was observed.^{39,40}

Anti-osteoporotic activity

Anti-osteoporotic activity has been reported by leaves. A new carbazole alkaloid 8,8 " -biskoeningine which is a balanced dimer of the carbazole and koeningine was found to be effective in cathepsin B model with IC₅₀ of 1.3 µg/mL.⁴¹

Inotropic activity

Positive inotropic effect was studied by Shah *et al.*, 2006 with the help of ethanolic extract of leaves in a dose dependent manner, that were been tested on an isolated frog heart. The increase in availability of calcium from extracellular sites showed the activity of leaves to increase contraction of the heart and hence showed positive results for leaves of *Murraya koenigiil* as inotropic agent.⁴²

Mosquitocidal and larvacidal activity

Das *et.al* has reported mahanimbine toxicity in contradiction of the larvae of *Culex quinquefasciatus*.⁴³ Petroleum ether extract and the acetone extracts of *Murraya koenigii* leaves serves as larvacide for *Aedes aegypti*.⁴⁴ Chloroform and methanol extracts of *Murraya koenigii* from stem bark showed strong activity against *Aedes aegypti*, a dengue Fever mosquito.⁴⁵

Effect on dental caries

Feeding leaves of *Murraya* has already been practiced since old times to cure dental problems but experimentally it was observed in golden hamsters that were fed on leaves and extracts. Isomahanine, Murrayanol and Mahanine were found to be the active ingredients in the same. The leaves could be thought of in use in toothpaste, oral gargles, chewing gums etc. to prevent oral problems and dental caries.^{46,47}

Hypoglycemic effects

According to the experiment on rats, aqueous and methanolic extract of *Murraya koenigii* leaves reduced the



plasma glucose levels in the alloxan induced rats. The ethanolic extract of stem of *Murraya koenigii* reported a remarkable reduction in the blood glucose level, triglyceride, total cholesterol level and body weight. Mahanimbine from leaves of *Murraya koenigii* was found to show antihyperglycemic and hypolipidemic activity. Furthermore, mahanimbine showed alpha-amylase as well as alpha-glucosidase inhibitory effects compared with the synthetic drug, acarbose.^{48,49} *Murraya koenigii* lowers the HFFD induced hyperlipidemia in rats.⁵⁰ Anti-hyperglycaemic and anti-obesity effects of *Murraya koenigii* leaves were also reported in another studies.⁵¹

When administered with a dose of 450 mg/ kg/ day, daily in high-fat diet (HFD)-induced obese rats, for 3 weeks. The ethyl acetate and dichloromethane extracts of curry leaves reduced the body weight, triglyceride and total cholesterol levels gained by the rats. These results showed the potential role of *Murraya koenigii* leaves to prevent obesity. Abnormality of lipid which is a common scenario in diabetes patients showed significant positive results.

Mahanimbine was found to be the responsible bioactive molecule against all.⁵²

Uses as cosmetics

Leaves of *M. koenigii* have already been used as a skin disinfectant. Bathing from luke warm water having leaves extracts is said to cure infections on the skin. Other than this, the potential of leaves in cosmetics has also been identified. Accordingly, it has been found to act in skin-lightening and moisturizing due to the presence of antioxidants and hyaluronidase inhibitory activity. The herbal formulation has been tried out in creams that in turn showed skin lightening and improvement in texture. Other than this sun protection activity was also studied and found that of could be used to enhance natural pigmentation and could be used as additives.⁵³

Bioactive Compounds

A number of bioactive compounds were reported from *Murraya koenigii* as summarized in table 1.

Table 1: bioactive compounds from *Murraya koenigii* with reported activity

Phytochemical reported	Source	Biological activity identified	References
Carotene	Leaves	Anti-oxidant activity	54
O- methyl mahanine	Leaves	Anti-oxidant activity	54,55
Lutein	Leaves	Anti-oxidant activity	55
Koenimbine	Leaves	Anti-oxidant activity, Anti-Diabetic, Anthelmintic Activity, Anti-Amnesic, Anti-diarrheal, chemoprotective, heamotological activity, nephroprotective	22, 56
Tocopherol	Leaves	Hepatoprotective activity, Anti-oxidant activity	57
O-methyl murrayamine A	Leaves	Anti-oxidant activity	55
Bispyrafoline	Leaves	Anti-oxidant activity	22,55,
Mahanine	Leaves, Stem and bark	Anti-caries, Anti-oxidant activity, Anti-microbial, Hepatoprotective activity, Topoisomerase I and II inhibitory activity, Anti- cancerous, for bronchial disorders, Anthelmintic Activity, Wound healing, activity against radiations, immunomodulatory, analgesic, Anti-inflammatory	24, 22, 58
Bismurrayafoline E	Leaves	Anti-oxidant activity	55
formyl carbazole	Leaves	Anti-bacterial and Anti-fungal activity	59
Mahanimbine	Leaves, Stem and bark	Mosquitocidal, Anti-microbial, Hepatoprotective, Anti-oxidant activity, Topoisomerase I and II inhibitory activity, Anti-fungal, Anti- cancerous , Wound healing, Anti-ulcer, immunomodulatory, analgesic, Anti-inflammatory	60
Murrayacine,	Leaves, stem	Anti-Diabetic, Anti-pyretic	26
Murrayazolinine	Leaves, seeds	Anti-Diabetic , vasodilation, Anti-pyretic, hepatoprotective	61
Mahanimbilol	Leaves	Anti-Trichomonal, vasodilation	12
Girinimbine	Leaves	Anti-Trichomonal, Anti- cancerous , for bronchial disorders, cardio-protective, Anti-cytotoxic, hepatoprotective, analgesic, Anti-inflammatory	62
Murrayafoline	Leaves	Anti- cancerous, activity against radiations , Anti-cytotoxic, immunomodulatory	63
Isomahanine	Leaves	Effect on dental caries	54,59, 64
Murrayanol	Leaves, stem, roots	Effect on dental caries	59, 65
Mahanimbicine	Leaves, stem	Wound healing, Anti-Amnesic, heamotological activity	65,66
Kurryam	Leaves	Anti-diarrheal	35
Girinimbiol	Leaves	cardio-protective	40
Koenoline	Leaves, seeds	Anti-cytotoxic	9
Isomahanimbine	Leaves, fruits	Anti- Alzheimer's activity, analgesic, Anti-inflammatory	67
Murrayazolidine	Leaves, stem	Anti- Alzheimer's activity	67



DISCUSSION AND CONCLUSION

Recent studies are much supporting for the phytochemicals are being investigated from foods for prevention of diseases. A large number of edible plants which have been used as medicines and foods by the Indian people since ancient times are generating paths for the discovery of novel physiologically active compounds with medicinal properties. The most important factor related to these compounds is the nullified side-effects that have a benefit over other medical treatment of present times mainly allopathic, which accounts for many uneasy problems for the patient. India is biodiversity hot spot and has many varieties of plant species carrying medicinal properties in this row, *Murraya koenigii*, a plant used in Indian culinary as a spice is found to carry a treasure of phytochemicals. It is very interesting to know that crude organic extracts isolated from *Murraya koenigii* leaves have been assessed for the few pharmacological activities. They have exhibited lipid-lowering, Anti-diabetic, anti-diarrheal, Anti-oxidant, cytotoxic, Anti-microbial and Anti-ageing property. Additionally, the other plant parts such as leaves, seeds and seed oil also have important medicinal benefits and they need to be examined scientifically for their therapeutic properties. Further in future, there is a need to evaluate the isolated phytochemicals from the plant for the benefit of mankind. It can be achieved by using scientific experimental animal models and clinical trials to get the information about their action mechanism on the molecular level.

REFERENCES

- Gurib FA, Medicinal plants: Traditions of yesterday and drugs of tomorrow, *Molecular Aspects Med*, 27, 2006, 1-93.
- Bonde SD, Nemade LS, Patel MR, Patel AA, *Murraya koenigii* (Curry leaves): Ethnobotany, phytochemistry and pharmacology - A review, *International Journal of Pharmacy and Phytopharmacological Research*, 1, 2011, 23-7.
- Jain V, Momin M, Laddha K, *Murraya Koenigii*: An Updated Review, *International Journal of Ayurvedic and Herbal Medicine*, 2, 2012, 607-627.
- Singh S, More PK, Mohan SM, Curry leaves (*Murraya koenigii* Linn. Sprengal)-a miracle plant, *Indian Journal of Scientific Research*, 4, 2014, 46-52.
- Gupta GL, Nigamurraya SS, Chemical examination of the leaves of *Murraya koenigii*. *Planta Med*, 19, 1970, 83.
- Adebajo AC, Olayiwola G, Verspohl EJ, Iwalewa EO, Omisore NOA, Bergenthal D, *et.al*, Evaluation of the ethnomedical claims of *Murraya koenigii*, *Pharm Biol*, 42, 2004, 610-620.
- Ponnusamy S, Ravindran R, Zinjarde S, Bhargava S, Ravi Kumar A, Evaluation of traditional Indian anti-diabetic medicinal plants for human pancreatic amylase inhibitory effect in vitro, *Evid Based Complement Alternat Med*, 2010
- Chakrabarty M, Nath A, Khasnabis S, Chakrabarty M, Konda Y, Harigaya Y, Komiyama K Carbazole alkaloids from *Murraya koenigii*, *Phytochemistry*, 46, 1997, 751-755.
- Nutan MTH, Hasnat A, Rashid MA, Anti-bacterial and cytotoxic activities of *Murraya koenigii*, *Fitoterapia*, 69, 1998, 173-175.
- Goutam MP, Purohit RM, Anti-microbial activity of the essential oil of the leaves of *Murraya koenigii*, *Indian Journal of Pharmacy*, 36, 1974, 11.
- Harbi HA, Irfan UM, Ali S, The antibacterial effect of curry leaves (*Murraya Koenigii*), *European Journal of Pharmaceutical and Medical Research*, 3, 2016, 382-387.
- Kishore N, Dubey NK, Tripathi RD, Singh SK, Fungitoxic activity of leaves of some higher plants, *National Academy Science Letters*, 5, 1982, 9.
- Rajnikant, Saima K, Chattree A, Antioxidant and Antifungal Potential of *Murraya koenigii* Leaves Extracts (Crude) and Essential Oil, *Chemical Science transactions*, 4, 2011, 222-226.
- Fumihiko T, Yamazaki Y, Koji S, Oral disinfectant formulations, *KokaiTokkyoKoho*, 8, 1995, 231.
- Bhattacharya K, Samanta SK, Tripathi R, Mallick A, Chandra S, Pal BC, *et al*, Apoptotic effects of mahanine on human leukemic cells are mediated through crosstalk between Apo-1/Fas signaling and the Bid protein and via mitochondrial pathways, *BiochemPharmacol*, 79, 2010, 361-372.
- Noolu B, Ajumeera R, Chauhan A, *et al*, *Murraya koenigii* leaves extract inhibits proteasome activity and induces cell death in breast cancer cells, *BMC Complementary and Alternative Medicine*, 13, 2013, 7.
- SamantaSK, KandimallaR, GogoiBj, Dutta KN, Choudhury P, De PK, Devi R, Pal BC, Talukdar NC, Phytochemical portfolio and anticancer activity of *Murraya koenigii* and its primary active component, mahanine, *Pharmacological Research*, 129, 2018, 227-236.
- AmnaUlil, Halimatussakdiah, Wahyuningsih P, Saidi N, Nasution R, Evaluation Of Cytotoxic Activity From Temurui (*Murraya koenigii* [Linn.] Spreng) Leaf Extracts Against Hela Cell Line Using MTT Assay, *Journal of Advance Pharmaceutical Technology and Research*, 10, 2019, 51-55.
- Khan BA, Abraham A, Leelamma S, *Murraya koenigi* and *Brassica juncea*--alterations on lipid profile in 1-2 dimethyl hydrazine induced colon carcinogenesis, *Invest New Drugs*, 14, 1996, 365-369.
- Shah AS, Wakade AS, Juvekar AR, Immunomodulatory activity of methanolic extract of *Murraya koenigii*(L) Spreng. Leaves, *Indian Journal of Experimental Biology*, 46, 2008, 505-509.
- Ramachandran S, Iatha VM, Charan SN, Dhanaraju M.D, Immunomodulatory Activity Of Methanolic Extract Of *Murraya Koenigii* Leaves Against Azathioprine Induced Immunosuppression In Laboratory Animals, *Int. Res. J. Pharm*, 6, 2015, 658-662.
- Gupta S, Prakash J, Studies on Indian green leafy vegetables for their anti-oxidant activity, *Plant Foods Hum Nutr*, 64, 2009, 39-45.
- Mitra E, Ghosh AK, Ghosh D, Mukherjee D, Chattopadhyay A, Dutta S, *et al*, Protective effect of aqueous Curry leaves (*Murraya koenigii*) extract against cadmium-induced oxidative stress in rat heart, *Food Chem Toxicol*, 50, 2012, 1340-1353.



24. Firdaus SB, Ghosha D, Chattopadhyay A, Duttaa M, Paul S, Janac J, Basua A, Bosea G, Lahiri H, Banerjee B, Pattari S, Chatterjee S, Jana K, Bandyopadhyay D, Protective effect of antioxidant rich aqueous curry leaf (*Murraya koenigii*) extract against gastro-toxic effects of piroxicam in male Wistar rats, Toxicology Reports, 1, 2014, 987-1003.
25. Zahin M, Aqil F, Husain FM, Ahmad I, Antioxidant Capacity and Antimutagenic Potential of *Murraya koenigii*, Biomedical research international, 2013, Article ID 263509.
26. Purohit SS, Sharma AK, Prajapati ND, Kumar T, A handbook of medicinal plants: a complete source book. Edition 2. Jodhpur: Agrobios (India), 2, 2009, 352-353.
27. Patel M, Pawar RS, Nephroprotective effect of *Murraya koenigii* on cyclophosphamide induced nephrotoxicity in rats, Asian Pacific Journal of Tropical Medicine, 10, 2017, 808–812.
28. Patel VR, Patel MG, Patel RK, Anti-pyretic activity of the ethanolic extract of the powdered leaves of *Murraya Koenigii*, Spreng, Journal of Pharmacy Research, 2, 2009, 731-732.
29. Rageeb MD, Usman MD, Barhate SD, Phytochemical evaluation and effect of antipyretic activity on *Murraya koenigii* Spreng. Leaves extract, International Journal of Pharmaceutical and Chemical Sciences, 1, 2012, 231–236.
30. Pokala N, Sayeli VTJ, Evaluation of antipyretic activity of alcoholic extract of *Murraya koenigii* leaves in rabbits, International Journal of Basic & Clinical Pharmacology, 2019, DOI: <http://dx.doi.org/10.18203/2319-2003.ijbcp20192653>.
31. Pagariya A, Chatur S, Nawab F, *In vitro* anthelmintic activity of root extract of *Murraya koenigii* (linn) spreng, International Journal of Pharmaceutical Innovations, 3, 2013, 111–114.
32. Molla SH, Bandyopadhyay PK, *In vitro* and *in vivo* anthelmintic activity of *Murraya koenigii* against gastrointestinal nematodes of sheep, Journal of Parasitic Diseases, 40, 2016, 362–368.
33. Kumar VS, Sharma A, Tiwari R, Kumar S, *Murraya koenigii* (curry leaves): a review, Journal of Medicinal and Aromatic Plant Science, 21, 1999, 1139-1141.
34. Sharma P, Vidyasagar G, Bhandari A, Singh S, Ghule S, Agrawal A, Goyal S, Panwar MS, Antiulcer Activity of Leaves Extract of *Murraya Koenigii* In Experimentally Induced Ulcer In Rats, Pharmacologyonline, 2, 2011, 818-824.
35. Rana VS, Juyal JP, Rashmi, Blazquez MA, Chemical constituents of the volatile oil of *Murraya koenigii* leaves, International Journal of Aromatherapy, 14, 2004, 23-25.
36. Sharma P, Vidyasagar G, Bhandari A, Singh S, Bhadoriya U, Ghule S, Dubey N et al., A pharmacological evaluation of anti-diarrhoeal activity of leaves extract of *Murraya koenigii* in experimentally induced diarrhoea in rats, Asian Pacific Journal of Tropical Disease, 2, 2012, 230-233.
37. Ramasamy A, Das S, Mani V, Sengottuvelu S, Vinoth PV, Evaluation of Anti-diarrheal potential of Hydro-alcoholic Extracts of Leaves of *Murraya koenigii* in Experimental Animals, 13, 2016, 393-401.
38. Kadam SH, Dombe S, Naikwadi P, Cardiovascular Effects of Aqueous Extract of *Murraya koenigii* on Isolated Perfused Frog Heart Preparation, Journal of Pharmacy Research, 4, 2, 2011, 462–463.
39. Phatak R, Matule S, Cardioprotective activity of *Murraya koenigii* leaves chloroform extract on thrombocyte indices in lead- intoxicated mice, conference paper, 2016.
40. Sandamali JAN, Ruwani P, Hewawasam, Kamani A P W, Jayatilaka, Mudduwa LKB, Research Article Cardioprotective Potential of *Murraya koenigii*(L.) Spreng. Leaf Extract against Doxorubicin-Induced Cardiotoxicity in Rat, Evidence-Based Complementary and Alternative Medicine, 2020, Article ID 6023737, 16 pages. <https://doi.org/10.1155/2020/6023737>
41. Rao BRR, Rajput DK, Mallavarapu GR, Chemical diversity in curry leaves (*Murraya koenigii*) essential oils, Food Chem, 126, 2011, 989-994.
42. Shah KJ, Juvekar AR, Positive inotropic effect of *Murraya koenigii*(Linn.) spreng extract on an isolated perfused frog heart, Indian J Exp Biol, 44, 2006, 481–484.
43. Das P B, Chowdhury D N, Choudhury B, Das GK, Choudhury TR, Studies On Some Alkaloids For Toxicity On The Larvae Of *Culex quinquefasciatus*, Indian Journal of Environmental Health, 38, 1996, 81-85.
44. Harith SS, Aziz SNASM, Phytochemical screening and larvicidal activity of *Murraya koenigii* leaves extracts against mosquito larvae, Malaysian Journal of Analytical Sciences, 22, 2018, 471-476.
45. Sukari MA, Noor HSM, Bakar NHA, Ismail IS, Rahmani M, Abdul AB, Larvicidal Carbazole Alkaloids from *Murraya koenigii* Against Dengue Fever Mosquito *Aedes aegypti* Linnaeus, Asian Journal of Chemistry, 14, 2013, 7719-7721.
46. Keishiro I, Shinichi N T M, Satoe N, Foods Containing *Murraya* Extract For Prevention And Control Of Bad Breath Jpn, KokaiTokkyoKoho, 1996, 8.
47. Fumihiko T, Yoji Y, Koji S, Oral Disinfectant Formulations, Jpn, KokaiTokkyoKoho, 1995, 6.
48. Vinuthan MK, Kumar GV, Ravindra JP, Jayaprakash, Narayana K, Effects of extracts of *Murraya koenigii* leaves on the levels of blood glucose and plasma insulin in alloxan induced diabetic rats, Indian Journal of Physiology and Pharmacology, 48, 2004, 348-352.
49. Prabhu KA, Tamilanban T, Investigation of antidiabetic activity of stem of *Murraya koenigii*, International Journal of Research in Pharmacology and Pharmacotherapeutics., 1, 2012, 165-168.
50. Phatak RS, Khanwelkar CC, Matule SM, Datkhile KD, Hendre AS, Antihyperlipidemic Activity of *Murraya koenigii* Leaves Methanolic and Aqueous Extracts on Serum Lipid Profile of High Fat-Fructose Fed Rats. Pharmacognosy Journal, 11(4), July 2019, 836-841.
51. Tembhrne SV, Sakarkar DM, Anti-obesity and hypoglycemic effect of ethanolic extract of *Murraya koenigii* (L) leaves in high fatty diet rats, Asian Pacific Journal of Tropical Disease, 2012, 166-168.
52. Iyer UM, Mani UV, Studies on the effect of curry leaves supplementation (*Murraya koenigii*) on lipid profile, glycated proteins and amino acids in non-insulin-dependent diabetic patients, Plant Foods Hum Nutr, 1990.
53. Tsuneo N, Yukio H, Kenji S, Masami N, Extraction of Hyaluronidase Inhibitors Form *Azadirachta indica* Or Other Plants for Manufacturing Cosmetics or For Therapeutic Use, Jpn, KokaiTokkyoKoho, 7, 1993, 72-79.



54. Narasimhan NS, Paradkar MV, Chitguppi VP, Kelkar SL. Alkaloids of *Murraya koenigii*, Structures of mahanimbine, koenimbine, mahanine, koenine, koenigine and koenidine. Indian Journal of Chemistry, 13, 1975, 993.
55. Tachibana Y, Kikuzaki H, Lajis NH, Nakatani N, Anti- Oxidative Activity of Carbazoles Form *Murraya koenigii* Leaves, J. Agric. Food. Chem, 49, 2001, 5589-5594.
56. BN Parimi, R Mopuri, B Meriga, The protective effect of leaves against carbon tetra *Murraya koenigii* chloride-induced hepatic damage in rats. Journal of Coastal Life Medicine, 2, 2014, 313-318.
57. Sathaye S, Amin PD, Mehta VB, et al, Hepatoprotective activity of *Murraya koenigii* against ethanol induced liver toxicity model in experimental animals, International Journal of Pharma and Bio Sciences, 3, 2012, 430–438.
58. Singh L, Sharma M, Anti-fungal properties of some plant extracts, Geobios, 5, 1978, 49.
59. Yankuzo H, Ahmed QU, Santosa RI, Akter SF, Talib NA, Beneficial effect of the leaves of *Murraya koenigii* (Linn.) Spreng (Rutaceae) on diabetes-induced renal damage in vivo, Journal of Ethnopharmacology, 135, 2011, 88-94.
60. Tachibana Y, Kikuzaki H, Lajis NH, Nakatani N, Anti-Oxidative Activity of Carbazoles From *Murraya koenigii* Leaves, J. Agric. Food. Chem, 49, 2001, 5589-5594.
61. Adesina SK, Olatunji OA, Brgenthal D, Reisch J, New Biogenetically Significant Constituents of *Clausena anisata* And *Murraya koenigii*, Pharmazie, 43, 1988, 221-222.
62. Ramsewak RS, Nair MG, Strasburg GM, Dewitt DL, Nitiss JL, Biologically Active Carbazole Alkaloids from *Murraya koenigii*, J. Agric Food. Chem, 47, 1999, 444-447.
63. Xie JT, Chang WT, Wang CZ, Mehendale SR, Li J, Ambihaipahar, R, et.al., *Murraya koenigii* reduces blood cholesterol and glucose level in ob/ob mice, American Journal of Chinese Medicine, 34, 2006, 279-284.
64. Paul S, Bandyopadhyay TK, Bhattacharyya A, Immunomodulatory effect of leaves extract of *Murraya koenigii* in diabetic mice, Immunopharmacol Immunotoxicol, 33, 2011, 691–699.
65. Patidar DK, Yadav N, Nakra V, et al, Wound healing activity of *Murraya koenigiil* eaves extract, *Int J Compr Pharm*, 4, 2010, 1–2.
66. Vasudevan M, Parle M, Antiamnesic potential of *Murraya koenigii* leaves, Phytotherapy Research, 23, 2009, 308–316.
67. Prakash V, Natarajan CP, Studies on Curry Leaves, J. Food Sci. And Technol, 11, 1974, 284-286.

Source of Support: Nil, Conflict of Interest: None.