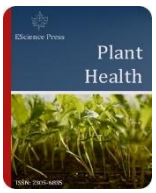
OPEN ACCESS Plant Health 04 (01) 2025. 13-20 DOI: 10.33687/planthealth.04.01.5209

Check for updates



Available Online at EScience Press
Plant Health
ISSN: 2305-6835
https://esciencepress.net/journals/planthealth

Phytochemistry and Biological Activities of *Murraya koenigii*

[a]Sana Khan, [a]Javeria Anwar, [b]Shahzadi Tabassam, [a]Muhammad Asad Anwar*
a Department of Bioinformatics and Biosciences, Capital University of Science and Technology, Islamabad, Pakistan.
b Department of Biology, Margalla Educational Institutions Shahrah-e-Stadium, Rawalpindi Pakistan.

ARTICLE INFO

Article History
Received: January 23, 2025
Revised: March 19, 2025
Accepted: May 11, 2025

Keywords
Murraya koenigii
Phytochemicals
Alkaloids
Hepatoprotective
Antioxidant properties

ABSTRACT

Murraya koenigii, which belongs to the family *Rutaceae*, is a medicinal plant; commonly known as curry leaves, that is rich in phytochemicals. Phytochemicals are bioactive compounds that can be used as sources for the prevention and treatment of many diseases. It is an aromatic plant commonly found in Southeast Asia. The leaves of the plant are used as a spice in food. Ethnobotanically, it has been used to fight infections, enhance immunity, and treat various diseases. It comprises several phytochemicals such as alkaloids, phenols, essential oils, tocopherol, carotene, terpenoids, and lutein, as well as minerals, proteins, and fats. Different parts of plants possess biological activities like antibacterial properties, antifungal, anti-diabetic, hepatoprotective, immunomodulatory, nephroprotective, and antioxidant properties. This review highlights the phytochemistry and biological activities of *M. koenigii*.

Corresponding Author: Muhammad Asad Anwar
Email: anwar.asad1@gmail.com

INTRODUCTION

Murraya koenigii, also known as "curry leaf" or "Kari patta" (Rana and Yamini, 2022), is a commonly used aromatic plant in South Asia, particularly in India and Pakistan. It has been used for centuries for its medicinal properties and as a spice in culinary. This plant belongs to the family *Rutaceae* (Abuga *et al.,* 2020) and is a deciduous shrub of about 16–15 inches or a small tree of about 3-5 meters with woody stems and smooth leaves (2-4 cm long) that are strongly aromatic. It also has small white, 5-petaled fragrant flowers (Sharma *et al.,* 2020). It is an edible small, glandular berry clustered closely, enclosing two green seeds and blackens when ripe (Abeysinghe *et al.,* 2021). According to the "Flora of Pakistan," the curry leaf plant is commonly found along the foothills of the Himalayas and has spread to other regions due to migration, from the River Ravi toward Tamil Nadu and Assam and to Chittagong in Pakistan, India, and Bangladesh, respectively (Datta *et al.,* 2023). *M. koenigii* has been utilized as a medicinal plant, flavorant, and aromatic with widespread ethnobotanical use for centuries. This plant's dried leaves are often used as a seasoning in Pakistani cuisine. The various parts of the curry leaf plant, including the stems, bark, seeds, fruits, roots, and leaves, play a significant role in fighting infection and boosting immunity. Consuming the leaves raw cure dysentery and the extract of its root is administered to control kidney pain and reduce fever (Azmin *et al.,* 2020). In traditional Ayurveda, curry leaves are used to treat hypertension, hysteria, cough, rheumatism, and hepatitis (Raghu, 2020). *M. koenigii* has a variety of chemical components that interact to produce its pharmacodynamic response. The presence of phytochemicals such as alkaloids, essential oils, phenolics, terpenoids, tocopherol, β-carotene, and lutein, as well as minerals, proteins, and fat, has been suggested as the cause of the bioactivity of curry leaf. Although the curry leaf plant produces a relatively small number of

phytochemicals, it possesses hepatoprotective, anti hypercholesterolemic, anti-diabetic, diabetic, antibacterial, anti-inflammatory, and antioxidant activities (Balakrishnan *et al.,* 2020). The pathogenesis of various conditions involves the participation of reactive oxygen and nitrogen species, which include free radicals. A living organism must maintain an equilibrium between the formation of reactive species and their accumulation in cells and tissues, as well as the biological system's capacity to detoxify them. The absence of this balance results in oxidative stress, which occurs when the concentration of reactive species is too high, leading to harmful effects on humans, plants, and animals. Antioxidants used in medicine and industry can be classified into; natural and synthetic. Synthetic antioxidants, which are commonly used, are believed to have detrimental effects on the human body, prompting a shift toward natural antioxidants derived from plants (Sen and Chakraborty, 2011). One of the most prominent natural antioxidant groups is polyphenolic compounds that possess one or more hydroxyl groups within their chemical structure. These compounds can be grouped into two main classes: phenolic acids and flavonoids (Olszowy, 2019). Different organic bioactive compounds like crystalline glycosides, carbazole alkaloids, koenigii, girinimbin, iso-mahanimbin, koenine, koenidine, and koenimbine have exceptional antioxidant properties (Asema *et al*., 2021). The mechanism of action of the antioxidant activity of curry leaves involves the ability of these phytochemicals to scavenge free radicals and reactive oxygen species (ROS) in the body by neutralizing free radicals after donating an electron or hydrogen atom to stabilize them and prevent further damage. Curry leaves' antioxidant qualities are attributed to their ability to activate innate antioxidant enzymes such as glutathione peroxidase, catalase, and superoxide dismutase (Gill and Sharma, 2014; Rehana *et al.,* 2017).

It was discovered that the antioxidant effect may be caused by the plant's high total phenol and flavonoid content, as well as its capacity to scavenge free radicals (Aryal *et al.,* 2019).

In both conventional and modern medicine, plants with medicinal characteristics are used to promote wellness, treat specific diseases, or both. Numerous phytochemicals that have either been proven to have biological action or may do so have been found in plants. Terpenes, alkaloids, glycosides, and polyphenols are the four main biochemical subcategories of phytochemicals, which are substances found in plants. In poor nations and non-industrialized communities, medicinal plants are widely employed because they are effective and inexpensive compared to modern medicine and are easily accessible (Ahn, 2017). Since their antiquity, plants have been used as medicines; however, their effectiveness is not always certain. Some of these plants are now used as culinary spices and herbs. Several plant classes contain polyphenols (Tapsell *et al*., 2006).

Punicalagins, a class of polyphenols found in astringent pomegranate peels, are a popular type of medicine (Jindal and Sharma, 2004). For a long time, gynecological diseases have been treated with the plant Angelica, which contains phytoestrogens (European Food Safety Authority, 2010). Cardiac glycosides such as digitoxin and digoxin are strong medications that improve heart function and have diuretic properties. These flowers are produced from medicinal plants, including the lily of the valley and foxglove (Wang *et al.,* 2013; Chan and Lin, 2009). Many medicinal plants, as well as resinous species like conifers, contain a variety of terpenoids and terpenes, which are highly fragrant and have many medical applications (Wiart, 2014). For instance, thymol, which has antibacterial properties, was previously used as an anthelmintic. Traditional local medicine, such as herbalism, is typically the primary healthcare source for people in developing nations (Awuchi and Godswill, 2019).

Taxonomic classification of *Murraya koenigii*

Taxonomic classification of *Murraya koenigii* is given in Table 1.

Table 1. Classification of *M. koenigii.*

Kingdom	*Plantae*
Division	*Magnoliophyta*
Class	*Magnoliospida*
Order	*Sapindales*
Family	*Rutaceae*
Genus	*Murraya*
Species	*Koenigii*

Figure 1. Curry leaf plant**.**

Phytochemicals of *Murraya koenigii*

Curry leaves contain abundant essential phytochemicals and secondary metabolites that impart diverse biological activities. These compounds include alkaloids, flavonoids, triterpenes, tannins, and unsaturated steroids, among others (Abeysinghe *et al.,* 2021). Rajendran *et al. (*2014) reported that various alkaloids such as mahanine, koenine, koenigine, koenidine, girinimbiol, girinimibine, and koenimbine, as well as O-methyl murrayamine A, isomahanine, bismahanine, and bispyrayafoline, have been isolated from curry leaves. The leaves also contain coumarin, glycosides, scopotin, and murrayanine, as well as minerals and vitamins such as iron, oxalic acid, niacin, calcium, riboflavin, carotene, and vitamin C.

Fresh and young curry plant leaves are rich in yellow volatile oils that are abundant in various essential nutrients, such as vitamin A, vitamin C, minerals, carotene, and carbohydrates. They also contain girinimbin, iso-mahanimbin, koenine, koenigine, koenidine, and koenimbine. In contrast, mature leaves are composed of different components, such as moisture, total nitrogen, fat, total sugar, and starch (Gahlawat *et al.,* 2014). The bark of curry plants contains carbazole alkaloids such as murrayacine and murrayazolidine in the alcoholic extract (Fiebig *et al.,* 1985). According to Mittal *et al. (*2017), the fruit pulp of the blackberries of curry plants is also a source of essential nutrients. The roots of the curry plant contain girinimbine, murrayanol, and murrastifoline-F, as well as bismahanine among others (William *et al.,* 2009). Lastly, the seeds of *M. koenigii* contain various chemical compounds, including girinimbine, koenimbine, isomahanine, and mahanine, as well as koenimbine and koenine (Gahlawat *et al.,* 2014; Mandal *et al.,* 2010).

Alkaloids and flavonoids derived from plants are essential for various biological activities and have medicinal and physiological importance. Steroids and tannins are other substances with strong antimicrobial properties, and polyphenolic flavonoids interact with the cell walls of bacteria via their mechanism of action (Pietta, 2000). Phenolic compounds are also important phytoconstituents and are believed to be the most well-known aromatic secondary metabolites, as reported by Abeysinghe *et al. (*2021). A type of phenolic compound known as flavonoids is present in medicinal plants and is responsible for imparting antioxidant activity. Furthermore, the total phenol concentration determines the final antioxidant activity (Aryal *et al.,* 2019). Previous studies have identified terpenes and carbazole alkaloids as the primary compounds responsible for *M. koenigii*'s antioxidant properties (Bisht and Gaurav, 2016).

Advantageous pharmacological properties of *M. koenigii*

There has been growing interest in the use of *M. koenigii* as a conventional medicine and herbal remedy in recent times. However, the extent of research conducted to evaluate the medicinal and pharmacological efficacy of *M. koenigii* for the treatment of diseases is limited (Balakrishnan *et al.,* 2018).

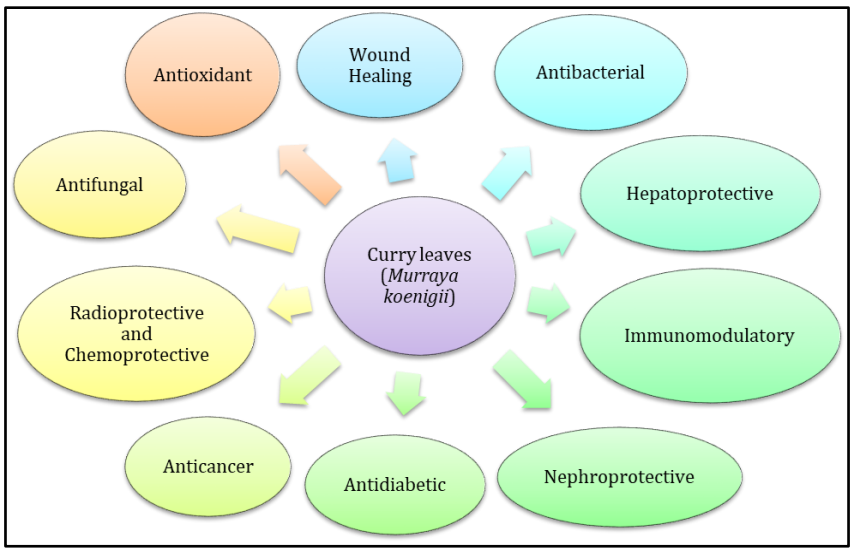


Figure 2. Biological activities of *Murraya koenigii*.

Hepatoprotective effect

One of the organs of the body, the liver, is greatly jeopardized by xenobiotics because it is responsible for the metabolism of drugs and for the detoxification of toxic substances (Manfo *et al.,* 2014). In experimental animal models, *M. koenigii* was found to have hepatoprotective properties, as demonstrated by its ability to protect against ethanol-induced hepatotoxicity. Furthermore, it efficiently maintains the enzymatic oxidant status and ameliorates liver impairment associated with chronic alcoholism (Shah *et al.,* 2015). The water and ethanolic extract of curry leaf were shown to diminish the hepatotoxic effects of CCl_4 in rats, as understood through the notable decrease in the levels of liver markers and maintenance of enzymatic antioxidants (Desai *et al.,* 2012).

Immunomodulatory activity

The immune system plays a crucial role in maintaining an organism's health by preventing the entry of microbes into the body. Disturbance of the immune system can result in various conditions, ranging from chronic inflammation to cancer (Kaufmann and Simon, 2015). This study evaluated the immunomodulatory effects of *M. koenigii* leaves extracted in methanol on antibody-mediated and cellular ovalbumin responses. The results showed a prominent increase in the production of nitric oxide radical (NO), indicating that the activity of macrophages in performing phagocytosis has increased. Therefore, *M. koenigii* extract can modulate the immune system by triggering antibody-mediated immunity and phagocytosis (Shah *et al.,* 2008).

Nephroprotective activity

M. koenigii has been tested in a rat model of diabetes to benefit from its nephroprotective effects (Yankuzo *et al.,* 2011). In that model, *M. koenigii* leaf extract effectively retained constant serum creatinine levels in addition to standard blood urea nitrogen, urinary urea, total urinary protein, serum sodium, creatinine, and urinary sodium levels. Additionally, in a study conducted in a rat model, the histopathology of kidneys revealed that the extract showed protective behavior similar to natural *in vivo* antioxidants, thus demonstrating its potential for treating disorders related to kidneys (Punuru *et al.,* 2014). In diabetic rats, *M. koenigii*'s protective activity dose-dependently decreased serum urea and creatinine levels while increasing plasma antioxidant capacity levels compared with controls. Notably, the aqueous extract induced comparable tissue regeneration in the kidneys and preserved histological integrity (Balakrishnan *et al.,* 2018).

Anti-diabetic activity

Diabetes mellitus is a metabolic disorder with serious health-related adverse effects. Various phytochemicals have been isolated from plants that exhibit antidiabetic effects. Alkaloids found in *M. koenigii* leaves have been studied and found to be useful in repressing aldose reductase, other enzyme systems, and glucose utilization, thereby extending their antidiabetic properties (Patel *et al.,* 2012). Furthermore, *M. koenigii* has been explored for its capacity to block alpha-glucosidase, which is frequently used for managing patients with type 2 diabetes widely (Gul *et al.,* 2012).

An extract of *M. koenigii* prepared in ethanol has been shown to significantly lower blood glucose levels due to the mimetic effects of insulin and mediation by its antioxidant properties, suggesting that *M. koenigii* has antidiabetic activity and antioxidant effects in rats (Husna *et al.,* 2018).

Anticancer activity

M. koenigii is a potential source of secondary metabolites with anticancer properties. A previous study evaluated the cytotoxic properties of three *M. koenigii* leaf extracts against HeLa cancer cells and found that they were potent in vitro (Amna *et al.,* 2019). Several in vivo cancer models and rodent cancer cell lines have also demonstrated *M. koenigii's* anticancer potential (Yeap *et al.,* 2015; Das *et al.,* 2014; Chatterjee *et al.,* 2015). In a study of colon neoplasms, histopathological evidence showed that treatment with *M. koenigii* extract repressed tumor growth (Iman *et al.,* 2017). In breast cancer cell lines, an extract of *M. koenigii* in methanol inhibited proliferation, and the total alkaloid derived from the leaves of the curry plant exhibited promising cytotoxic activity (Noolu *et al.,* 2013). These findings suggest that *M. koenigii* contains several anticancer compounds that show potential for further development as cancer treatments.

Antioxidant Activity of *Murraya koenigii*

Kusuma *et al. (*2011) reported that *M. koenigii* leaf extracts possess remarkable antioxidant properties. Rao *et al. (*2017) performed a DPPH free radical scavenging assay to test the antioxidant activity of water and ethanol extracts of *M. koenigii* leaves, with quercetin serving as the positive control. The ethanol extract exhibited a scavenging activity of 80%, comparable to that of quercetin. The DPPH free radical scavenging assay was used by Yogesh *et al. (*2012) to measure the antioxidant activity of *M. koenigii* berry extract. Tomar *et al. (*2017) conducted the H_2O_2 scavenging activity assays using acetone and petroleum ether extracts to determine the total antioxidant activity of younger and older *M. koenigii* leaves. They found that the acetone extract of older leaves had the highest activity at 151.58%, whereas the petroleum ether extract of younger leaves had a value of 72.23%. *M. koenigii* leaf extract may have antioxidant activity and counteract the oxidative stress brought on by diabetes, according to Arulselvan and Subramanian (2007). The aforementioned studies indicate that various *M. koenigii* extracts have different antioxidant activities.

CONCLUSION

In conclusion, curry leaves are a vital source of medicinal compounds, exhibiting diverse biological activities, such as anti-diabetic, hepatoprotective, immunomodulatory, anti-cancer, and antioxidant effects. Antioxidant properties, in particular, hold promise in combating aging and other diseases, such as cancer and cardiovascular diseases. Future research should investigate how different stressors affect the biological activity of curry leaves to potentially optimize their therapeutic potential. By delving deeper into their mechanisms of action, we can contribute to healthcare and scientific advancement. Curry leaves thus remain a promising resource in traditional and modern medicine, offering significant potential for improving human health.

CONFLICT OF INTEREST

The authors have not declared any conflict of interests.

REFERENCES

Abeysinghe, D. T., Kumara, K. A. H., Kaushalya, K. A. D., Chandrika, U. G., & Alwis, D. D. D. H. 2021. Phytochemical screening, total polyphenol, flavonoid content, *in vitro* antioxidant and antibacterial activities of Sri Lankan varieties of *Murraya koenigii* and *Micromelum minutum* leaves. *Heliyon*, *7*(7), e07449. https://doi.org/10.1016/j.heliyon.2021.e07449

Abuga, I., Sulaiman, S. F., Wahab, R. A., Ooi, K. L., & Rasad, M. S. B. A. 2020. In vitro antibacterial effect of the leaf extract of *Murraya koenigii* on cell membrane destruction against pathogenic bacteria and phenolic compounds identification. European Journal of Integrative Medicine, 33: 101010. https://doi.org/10.1016/j.eujim.2019.101010

Ahn K. 2017. The worldwide trend of using botanical drugs and strategies for developing global drugs. *BMB Reports*, 50 (3), 111–116. https://doi.org/10.5483/bmbrep.2017.50.3.221

Amna, U., Halimatussakdiah, Wahyuningsih, P., Saidi, N., & Nasution, R. 2019. Evaluation of cytotoxic activity from Temurui (*Murraya koenigii* [Linn.] Spreng) leaf extracts against HeLa cell line using MTT assay. *Journal of Advanced Pharmaceutical Technology and Research*, 10(2), 51–55. https://doi.org/10.4103/japtr.JAPTR_373_18

Arulselvan, P., & Subramanian, S. P. 2007. Beneficial effects of Murraya koenigii leaves on antioxidant defense system and ultrastructural changes of pancreatic beta-cells in experimental diabetes in rats. *Chemico-biological interactions*, *165*(2), 155–164. https://doi.org/10.1016/j.cbi.2006.10.014

Aryal, S., Baniya, M. K., Danekhu, K., Kunwar, P., Gurung, R., & Koirala, N. 2019. Total Phenolic Content, Flavonoid Content and Antioxidant Potential of Wild Vegetables from Western Nepal. *Plants (Basel, Switzerland)*, *8*(4), 96. https://doi.org/10.3390/plants8040096

Asema, S. U. K., Shaikh, A. A., Farooqui, M & Fatema, S. 2021. Phytochemical analysis of *Murraya koenigii* leaves extract and its biological activity. *The International Journal of Analytical and Experimental Modal Analysis*, 3(1), 1798-1801.

Awuchi, & Godswill, C. 2019. Medicinal plants: the medical, food, and nutritional biochemistry and uses. *International Journal of Advanced Academic Research*, 5(11), 220-241. DOI: https://www.researchgate.net/publication/337649086

Azmin, S. N. H. M., & Chng, H. Y. 2020. Physio-chemical properties of curry leaf. In *Curry Leaf (Murraya koenigii): The Story of a Potential Miracle Plant*, 26-28. LAMBERT Academic Publishing. DOI: https://www.researchgate.net/publication/340234052

Balakrishnan, R., Tamilselvam, K., Sulthana A., Mohankumar, T., Manimaran, D., & Elangovan, N. 2018. Isolongifolene attenuates oxidative stress and behavioral impairment in rotenone-induced rat model of parkinson's disease. *The International Journal of Nutrition, Pharmacology, Neurological Diseases*, 8, 53–58. DOI: 10.4103/ijnpnd.ijnpnd_3_18

Balakrishnan, R., Vijayraja, D., Jo, S. H., Ganesan, P., Su-Kim, I., & Choi, D. K. 2020. Medicinal Profile, Phytochemistry, and Pharmacological Activities of Murraya koenigii and its Primary Bioactive Compounds. *Antioxidants (Basel, Switzerland)*, *9*(2), 101. https://doi.org/10.3390/antiox9020101

Bisht, J. R., & Gaurav, N. 2016. Phytochemical analysis and antibacterial activity of different leaf extracts of *Murraya koenigii*. *International Journal of Biochemistry and Biomolecules*, 2(2), 1–5.

Chan, K., & Lin, T. X. 2009. Treatments used in complementary and alternative medicine. *Side Effects of Drugs Annual*, 31, 745–756. DOI:10.1016/S0378-6080(09)03148-1.

Chatterjee, P., Seal, S., Mukherjee, S., Kundu, R., Bhuyan, M., Barua, N. C., Baruah, P. K., Babu, S. P., & Bhattacharya, S. 2015. A carbazole alkaloid deactivates mTOR through the suppression of rictor and that induces apoptosis in lung cancer cells. *Molecular and cellular biochemistry*, *405*(1-2), 149–158. https://doi.org/10.1007/s11010-015-2406-2

Das, R., Bhattacharya, K., Samanta, S. K., Pal, B. C., & Mandal, C. 2014. Improved chemosensitivity in cervical cancer to cisplatin: synergistic activity of mahanine through STAT3 inhibition. *Cancer letters*, *351*(1), 81–90. https://doi.org/10.1016/j.canlet.2014.05.005

Datta, H. S., Bora, D., Purkayastha, M. D., Choudhury, M., & Neog, M. 2023. "*Murraya koenigii* (L.) Spreng." In *Himalayan Fruits and Berries*, edited by T. Belwal, I. Bhatt, and H. Devkota, 271–287. Academic Press, UK. DOI: https://doi.org/10.1016/b978-0-323-85591-4.00044-1

Desai, S. N., Patel, D. K., Devkar, R. V., Patel, P. V., & Ramachandran, A. V. 2012. Hepatoprotective potential of polyphenol rich extract of Murraya koenigii L.: an in vivo study. *Food and chemical toxicology: an international journal published for the British Industrial Biological Research Association*, *50*(2), 310–314. https://doi.org/10.1016/j.fct.2011.10.063

European Food Safety Authority. 2010. Scientific Opinion on the substantiation of health claims related to various food(s)/food constituent(s)… pursuant to Article 13(1) of Regulation (EC) No 1924/20061. *European Food Science Authority Journal*. 8(2): 1489. DOI: 10.2903/j.efsa.2010.1489.

Fiebig, M., Pezzuto, J. M., Soejarto, D. D., & Kinghorn, A. D. 1985. Koenoline, a further cytotoxic carbazole alkaloid from *Murraya koenigii*. *Phytochemistry,* 24(12), 3041–3043. DOI: https://doi.org/10.1016/0031-9422(85)80052-2.

Gahlawat, D. K., Jakhar, S., & Dahiya, P. 2014. *Murraya koenigii* (L.) Spreng: an ethnobotanical, phytochemical and pharmacological review. *Journal of Pharmacognosy and Phytochemistry,* 3(3), 109–119.

Gill, N. S., & Sharma, B. 2014. Study on Antioxidant Potential of *Murraya Koenigii* Leaves in Wistar Rats. *Pakistan Journal of Biological Sciences,* 17(1), 126–29. https://doi.org/10.3923/pjbs.2014.126.129.

Gul, M. Z., Attuluri, V., Qureshi, I. A., & Ghazi, I. A. 2012. Antioxidant and α-glucosidase inhibitory activities of Murraya koenigii leaf extracts. *Pharmacognosy Journal*, 4(32), 65–72. DOI: https://doi.org/10.5530/pj.2012.32.12.

Husna, F., Suyatna, F. D., Arozal, W., & Poerwaningsih, E. H. 2018. Anti-Diabetic potential of *Murraya koenigii* (L) and its antioxidant capacity in nicotinamide-streptozotocin induced diabetic rats. *Drug Research*, 68(11), 631–636. https://doi.org/10.1055/a-0620-8210

Iman, V., Mohan, S., Abdelwahab, S. I., Karimian, H., Nordin, N., Fadaeinasab, M., Noordin, M. I., & Noor, S. M. 2016. Anticancer and anti-inflammatory activities of girinimbine isolated from *Murraya koenigii*. *Drug design, development and therapy*, *11*, 103–121. https://doi.org/10.2147/DDDT.S115135

Jindal, K. K., & Sharma, R. C. 2004. Recent trends in horticulture in the Himalayas: integrated development under the mission mode. Indus Publishing.

Kaufmann, T., & Simon, H. U. 2015. Targeting disease by immunomodulation. *Cell Death and Differentiation*, 22(2), 185–186. https://doi.org/10.1038/cdd.2014.166

Kusuma, I. W., Kuspradini, H., Arung, E. T., Aryani, F., Min, Y. H., Kim, J. S., & Kim, Y. U. 2011. Biological activity and phytochemical analysis of three Indonesian medicinal plants, Murraya koenigii, Syzygium polyanthum and Zingiber purpurea. *Journal of acupuncture and meridian studies*, *4*(1), 75–79. https://doi.org/10.1016/S2005-2901(11)60010-1

Mandal, S., Nayak, A., Kar, M., Banerjee, S. K., Das, A., Upadhyay, S. N., Singh, R. K., Banerji, A., & Banerji, J. 2010. Antidiarrhoeal activity of carbazole alkaloids from Murraya koenigii Spreng (Rutaceae) seeds. *Fitoterapia*, *81*(1), 72–74. https://doi.org/10.1016/j.fitote.2009.08.016.

Manfo, F. P. T., Nantia, E. A., & Kuete, V. 2014. Hepatotoxicity and hepatoprotective effects of African medicinal plants. *In*: Kuete V. (ed.) *Toxicological survey of African medicinal plants*. 323-355. Elsevier.

Mittal, J., Jain, M., Gilhotra, R., & Singh, R. P. 2017. Curry leaf *(Murraya koenigii*): a spice with medicinal property. *MOJ Biology and Medicine,* 2(3), 236–256. https://doi.org/10.15406/mojbm.2017.02.00050

Noolu, B., Ajumeera, R., Chauhan, A., Nagalla, B., Manchala, R., & Ismail, A. 2013. Murraya koenigii leaf extract inhibits proteasome activity and induces cell death in breast cancer cells. *BMC complementary and alternative medicine*, *13*, 7. https://doi.org/10.1186/1472-6882-13-7

Olszowy M. 2019. What is responsible for antioxidant properties of polyphenolic compounds from plants?. *Plant physiology and biochemistry: PPB*, *144*, 135–143. https://doi.org/10.1016/j.plaphy.2019.09.039

Patel, D. K., Kumar, R., Laloo, D., & Hemalatha, S. 2012. Natural medicines from plant source used for therapy of diabetes mellitus: An overview of its pharmacological aspects. *Asian Pacific Journal of Tropical Disease,* 2(3), 139–150. https://doi.org/10.1016/S2222-1808(12)60054-1

Pietta P. G. 2000. Flavonoids as antioxidants. *Journal of natural products*, *63*(7), 1035–1042. https://doi.org/10.1021/np9904509

Punuru, P., Sujatha, D., Kumari, B. P., & Charisma, V. V. 2014. Evaluation of aqueous extract of Murraya koenigii in unilateral renal ischemia reperfusion injury in rats. *Indian journal of pharmacology*, *46*(2), 171–175. https://doi.org/10.4103/0253-7613.129310

Raghu B. R. 2020. Diversity and distribution of curry leaf in India." *Journal of Horticultural Sciences,* 15 (1), 1-8. https://doi.org/10.24154/JHS.2020.v15i01.001

Rajendran, M. P., Pallaiyan, B. B., & Selvaraj, N. 2014. Chemical composition, antibacterial and antioxidant profile of essential oil from Murraya koenigii (L.) leaves. *Avicenna journal of phytomedicine*, *4*(3), 200–214.

Rana, A., & Yamini. 2022. Antimicrobial properties and phytochemical analysis of different extracts of *Murraya koenigii*. Journal of Pharmacognosy and Phytochemistry, 11(6), 1-6.

Rao, L. J. M., Ramalakshmi, K., Borse, B. B., & Raghavan, B. 2007. Antioxidant and radical-scavenging carbazole alkaloids from the oleoresin of curry leaf (Murraya koenigii Spreng.). *Food Chemistry*, 100(2), 742–747. https://doi.org/10.1016/j.foodchem.2005.10.033

Rehana, D., Mahendiran, D., Kumar, R. S., & Rahiman, A. K. 2017. In vitro antioxidant and antidiabetic activities of zinc oxide nanoparticles synthesized using different plant extracts. *Bioprocess and biosystems engineering*, *40*(6), 943–957. https://doi.org/10.1007/s00449-017-1758-2

Sen, S., & Chakraborty, R. 2011. The Role of Antioxidants in Human Health. In Acs Symposium Series, 1–37. DOI: https://doi.org/10.1021/bk-2011-1083.ch001

Shah, A. S., Wakade, A. S., & Juvekar, A. R. 2008. Immunomodulatory activity of methanolic extract of Murraya koenigii (L) Spreng. leaves. *Indian journal of experimental biology*, *46*(7), 505–509.

Shah, P., Singh, S. P., & Kumar, A. 2015. Combined effect of hydroethanolic extracts of Murraya koenigii and Phyllanthus niruri leaves on paracetamol and ethanol-induced toxicity in HepG2 cell line. *Current Science*, 109(07), 1320–1326. https://www.jstor.org/stable/24905896

Sharma, N., Neha, M., & Kushwaha, N. 2020. A Review on the Activities of Aloe Vera and Curry Leaves. *International Journal of Recent Scientific Research,* 11(11), 39985-39991. http://dx.doi.org/10.24327/ijrsr.2020.1111.5602

Tapsell, L. C., Hemphill, I., Cobiac, L., Patch, C. S., Sullivan, D. R., Fenech, M., Roodenrys, S., Keogh, J. B., Clifton, P. M., Williams, P. G., Fazio, V. A., & Inge, K. E. 2006. Health benefits of herbs and spices: the past, the present, the future. *The Medical journal of Australia*, *185*(S4), S1–S24. https://doi.org/10.5694/j.1326-5377.2006.tb00548.x

Tomar, R. S., Banerjee, S., & Kaushik, S. 2017. Assessment of antioxidant activity of leaves of Murraya koenigii extracts and it's comparative efficacy analysis in different solvents. *Journal of Pharmaceutical Sciences and Research,* 9(3), 288–291.

Wang, Z., Ma, P., Xu, L., He, C., Peng, Y., & Xiao, P. 2013. Evaluation of the content variation of anthraquinone glycosides in rhubarb by UPLC-PDA. *Chemistry Central journal*, *7*(1), 170. https://doi.org/10.1186/1752-153X-7-170

Wiart C. 2014. Lead compounds from medicinal plants for the treatment of neurodegenerative diseases. Terpenes. 189–284.

William, F., Lakshminarayanan, S., & Chegu, H. 2009. Effect of some Indian vegetables on the glucose and insulin response in diabetic subjects. *International Journal of Food Sciences and Nutrition*, 44(3), 191–195. https://doi.org/10.3109/09637489309017439

Yankuzo, H., Ahmed, Q. U., Santosa, R. I., Akter, S. F., & Talib, N. A. 2011. Beneficial effect of the leaves of Murraya koenigii (Linn.) Spreng (Rutaceae) on diabetes-induced renal damage in vivo. *Journal of ethnopharmacology*, *135*(1), 88–94. https://doi.org/10.1016/j.jep.2011.02.020

Yeap, S. K., Abu, N., Mohamad, N. E., Beh, B. K., Ho, W. Y., Ebrahimi, S., Yusof, H. M., Ky, H., Tan, S. W., & Alitheen, N. B. 2015. Chemopreventive and immunomodulatory effects of Murraya koenigii aqueous extract on 4T1 breast cancer cell-challenged mice. *BMC complementary and alternative medicine*, *15*, 306. https://doi.org/10.1186/s12906-015-0832-z

Yogesh, K., Jha, S. N., & Yadav, D. N. 2012. Antioxidant Activities of Murraya koenigii (L.) Spreng Berry Extract: Application in Refrigerated (4 ± 1 °C) Stored Meat Homogenates. *Agricultural Research*, 1(2), 183–189. DOI: 10.1007/s40003-012-0018-6.