https://doi.org/10.48047/AFJBS.6.14.2024.5070-5092

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

A Comprehensive Review on the Morphology, Chemistry, and Multifaceted Applications of Curry Leaves

Jagamohan Meher[1], M. Geethu[2], G. Kalusuraman[3], Maheswari R.S, Nair[4], Ramswaroop Saini[5], J. Purushothaman[6]

[1]*Department of Agricultural Engineering, School of Agriculture, Mohan Babu University, Tirupati, Andhra Pradesh. jagamohan.m@mbu.asia*

[2]*Department of Agriculture, School of Agriculture Science, Joy University, Vadakangulam, Tamil Nadu. geethumsasikumar@gmail.com*

[3]*Department of Agricultural Engineering, Kalasalingam Academy of Research and Education, Krishnankoil, Srivilliputhur, Tamil Nadu. g.kalusuraman@klu.ac.in*

[4]*The Indian Agriculture College,Tirunelveli, Tamil Nadu. mahe.sreemangalam@gmail.com*

[5]*Department of Biotechnology, School of Allied Health Sciences, Joy University, Vadakangulam, Tamil Nadu. saini@joyuniversity.edu.in*

[6]*The Indian Agriculture College,Tirunelveli, Tamil Nadu. purushothj14@gmail.com*

Volume 6, Issue 14, Aug 2024

Received: 15 June 2024

Accepted: 25 July 2024

Published: 15 Aug 2024

doi: 10.48047/AFJBS.6.14.2024.5070-5092

Abstract-This review study discusses curry leaves, including their historical background, morphological properties, chemical composition, and several applications. There are 35 detailed morphological descriptions of the plant's leaves, flowers, and fruit. The chemical profile emphasizes the substantial phytochemical richness of curry leaves, which underpins their diverse biological functions. Curry leaves are investigated for a variety of applications, with an emphasis on their potent antioxidant, medicinal, anticarcinogenic, hepatoprotective, antibacterial, cardioprotective, antiobesity, antihyperlipidemic, antiamnesic, wound-healing, kidney protective, antipyretic, histopathological, and antidiarrheal properties. This comprehensive research highlights curry leaves' great therapeutic potential in both traditional and modern medicine. Given the limitations and adverse effects of synthetic substances, there is a renewed emphasis on identifying plant-derived molecules as safer alternatives. Curry leaves, a medicinal herb from the Rutaceae family, are commonly used in Ayurvedic medicine. Its leaves, roots, and bark are high in carbazole alkaloids, which have powerful biological and pharmacological effects such as antioxidant, antidiabetic, anti-inflammatory, anticancer, and neuroprotective properties. This study focuses on the principal components of curry leaves and their pharmacological activity, arguing for additional research to evaluate their efficacy as therapeutic agents in a variety of pathological diseases.

Keywords: Curry Leaves, Antioxidant, Bioactive Compounds, Pharmacological Activity, Traditional Medicine.

1. Introduction

Plants have been indispensable to human survival for millennia, serving as vital resources for food, clothing, and shelter. Their components have been globally utilized in medicine, food preservation, crafts, cosmetics, essential oils, flavoring, scented products, and dietary supplements. These applications not only contribute to health and well-being but also offer significant economic benefits, particularly in rural areas[1]. According to the World Health Organization, 80 percent of the population in developing nations depends on plant-based medicines for primary healthcare. A prime example of such a medicinal plant is the curry leaf. Historical texts from the first to fourth centuries AD in Tamil literature and later in Kannada literature highlight its use as a vegetable flavouring. Originating from tropical trees of the Rutaceae family, which includes about 150 genera and 1600 species, curry leaves, known as Kari Patta in India, were named "Murraya" in honour of John Adam Murray, a botany professor at the University of Gottingen [2]. In India and Sri Lanka, particularly in the southern regions, curry leaves are highly valued for their distinctive flavor and aesthetic appeal, with their use extending to Malaysia, South Africa, and Reunion Island. Native to India, Bangladesh, and Sri Lanka, curry leaves are now a profitable export commodity [3]. This small aromatic shrub or tree, growing up to 6 meters tall, features bright, glossy black leaves with a strong scent, white flowers in small clusters, and purplish-black, berry-like ripe fruits. The branches and leaves typically used fresh but sometimes dried, provide a potent, warming, spicy aroma and possess therapeutic properties.

Medicinal plants like Curry leaves are essential not only for healthcare and skincare but also for economic growth and cultural development, particularly in developing countries. The World Health Organization estimates that 80% of the global population relies on traditional medicine, supported by the substantial $19.4 billion global revenue for herbal remedies in 2010. The market for traditional medicinal plants is expanding, with an annual increase of 20% in India and significant usage in China, Thailand, and Germany. Murraya koenigii (L) Spreng, commonly known as "curry leaves," is prevalent in tropical and subtropical regions. Of the 14 global species in the Murraya genus, only Curry leaves and M. paniculata are found in India, with Curry leaves being particularly significant due to its extensive traditional medicinal properties. Known in Ayurvedic medicine as “krishnanimba,” various parts of the plant, such as leaves, roots, bark, and fruit, are recognized for their biological activities [4].

The leaves, slightly bitter and pungent, are used as anthelmintics, analgesics, digestives, and appetizers in Indian cuisine. They are also utilized to treat piles, inflammation, cuts, dysentery, bruises, and edema, while the roots and bark possess purgative and stimulating properties. Recent studies have highlighted the essential oil extracted from Curry leaves, showcasing antioxidative, hepatoprotective, antimicrobial, antifungal, anti-inflammatory, and nephroprotective activities in animal models. These medicinal properties are attributed to chemical constituents such as carbazole alkaloids and other metabolites like terpenoids, flavonoids, phenolics, carbohydrates, carotenoids, vitamins, and nicotinic acid [5].

Despite the growing interest in M. koenigii's use in traditional medicines and home remedies, limited research has evaluated its pharmacological and medicinal efficacy comprehensively. This review aims to discuss the traditional medicinal use of Curry leaves and their bioactive compounds, highlighting their pharmacological effects. By systematically categorizing, comparing, and summarizing phytochemical screenings, identifications, and pharmacological activities, this review seeks to provide a clear overview of the therapeutic potential of and guide future research endeavors.

2. Background and Historical Context of Curry Leaves

Curry leaf is a perennial leafy vegetable scientifically known as Murraya koenigii Spreng. Historical texts from the first to fourth centuries AD in Tamil literature and later in Kannada literature highlight its use as a vegetable flavoring. Originating from tropical trees of the Rutaceae family, which includes about 150 genera and 1600 species, curry leaves, known as Kari Patta in India, were named "Murraya" in honor of John Adam Murray, a botany professor at the University of Gottingen, and Johann Gerhard Konig, a German botanist. The taxonomy of the curry leaf plant is detailed in Table 1.1.

Murraya koenigii, commonly referred to as curry leaf, is a fragrant, pubescent shrub or small tree. It typically grows as undergrowth in forests throughout India, including the Andaman Islands. The curry leaf tree has become naturalized in forests and wastelands across the Indian subcontinent, except in the Himalayas. It is predominantly found in Chittagong, Bangladesh, Tamil Nadu, and southern parts of India, and has also spread to Malaysia and South Africa. Table 1.2 lists the names of curry leaves in various international and vernacular languages. Originating in the Tarai region of Uttar Pradesh, the plant is now extensively distributed across Uttaranchal, Sikkim, Bengal, Assam, Central India, the Western Ghats, Tamil Nadu, Maharashtra, Karnataka, and the hills of Kerala [6].

Curry leaves is widely used in Indian cooking for its fragrant leaves. It is recommended as a dietary supplement [7]. Whether fresh or dried, curry leaves are fried in oil to release their rich flavor and aroma [8]. The aromatic leaves are somewhat bitter, acerbic, cooling, and faintly acidic, maintaining their flavor and properties even after drying [9]. Traditionally, the plant has been a source of various vitamins and a remedy for diseases such as diabetes, cancer, influenza, rheumatism, and traumatic injury. Recent studies have highlighted the essential oil extracted from Curry leaves, showcasing antioxidative, hepatoprotective, antimicrobial, antifungal, anti-inflammatory, and nephroprotective activities in animal models. These medicinal properties are attributed to chemical constituents such as carbazole alkaloids and other metabolites like terpenoids, flavonoids, phenolics, carbohydrates, carotenoids, vitamins, and nicotinic acid[10].

Numerous studies have highlighted the antioxidant properties of curry leaves and investigated the phytochemical components of the leaves, stem, bark, and root [11]. Thus, curry leaves have extensive food and pharmacological applications in their natural form.

There is significant potential demand for this leafy spice if adequate and feasible processing and manufacturing procedures for bioactive products are established. This could lead to its use in the food industry. Despite curry leaves being a common ingredient in many processed foods and their recognized biological importance, their industrial applications remain underexplored due to technological limitations and inconsistent availability. For instance, the use of fresh leaves is limited, and while sun-dried leaves are used in some regions, they are often considered inferior due to unsanitary conditions and the loss of volatile oils and color.

3. Morphological Characteristics and Chemical Composition of the Curry Leaf Plant

The curry leaf plant, recognized as a spreading shrub, typically grows into a small tree reaching heights of 4 to 6 meters with a trunk diameter of up to 40 cm. Its compound leaves consist of 11 to 21 leaflets, each measuring 2 to 4 cm in length and 1 to 2 cm in width. The main stem, often dark green to brownish, bears distinctive spots and, upon longitudinal bark peeling, reveals white wood beneath. The stem itself boasts a girth of 16 cm [12]. Figure 1.1 provides a visual representation of the leaf, flower, and fruit of the curry leaf plant.

Table 1.1. Taxonomy of Curry Leaf

Kingdom	**Plantae**
Subkingdom	Tracheobionta
Superdivision	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Rosidae
Order	Sapindales
Family	Rutaceae
Genus	Murraya
Species	*Murraya koenigii*

Table 1.2. Vernacular names of curry leaf (Parmar, 1982)

Languages	**Name of Curry leaves**
French	Feuilles de curi
German	Curry blatter
English	Curry leaves
Chinese	Ga Lei Yihp
Dutch	Kerriebladeren
Spanish	Hoja
Hindi	Kathnim, Mitha Neem, Kurry Patta, Gandhela, Barsanga, Kari Patta
Orissa	Bassan, Basango, Bhursang,lesinga
Telugu	Karepaku
Tamil	Karuveppilei, Kattuveppilei, Karivempu, Kariveppilai
Assam	Narasingha, Bishahari

Malayalam	Kariveppilei
Kannada	Karibevu
Gujarati	Gorenimb, Kadhilimbdo
Bengali	Barsanga, Kartaphulli Gandhela
Sanskrit	Surabhinimba, Kalasaka, Mahanimb
Kashmiri	Mitha neem, Gandhla, Gandhela, Gandhe

Table 1.3. Nutrient composition of curry leaves

Constituents	**Contain (%)**	**Constituents**	**Contain (%)**
Protein	6 .1%	Potassium	10.3 - 30.3 mg/100 g
Fat (ether extract)	1 .0 %	Calcium	9.44 - 28.3 mg/100 g
Carbohydrate	18.7 %	Magnesium	1.14 - 7.19 mg/100 g
Fibre	6.4 %	Potassium	0.43 - 1.69 mg/100 g
Carotene (as vitamin A)	12600 IU/100g	Manganese	24.8 - 63.0 mg/100 g
Vitamin C	4mg/100g	Iron	72.5 - 195 mg/100 g
Nicotinic acid	2.3 mg/100g	Zinc	7.9 - 70.5 mg/100 g
Sodium	104 - 455 mg/100 g		

Leaf Morphology

A macroscopic analysis, reveals that the leaves are obliquely ovate or rhomboid, featuring an apex that can be acuminate, obtuse, or acute. These leaves are alternately arranged and bipinnately compound, with petioles ranging from 20 to 30 cm in length, each bearing 24 leaflets. Individual leaflets measure 4.9 cm in length and 1.8 cm in width, with a petiole length of 0.5 cm. Stomata are evident on both sides, exhibiting reticulate venation, while the leaves possess a dentate border with an irregular base [13].

Curry leaves are rich in carbohydrates, amino acids, proteins, minerals, vitamins A and B, and alkaloids. Table 1.3 offers an extensive overview of the functional attributes of curry leaves, renowned for their nutritional richness and health benefits [14].

Flower Morphology

Curry flowering typically begins in mid-April and concludes by mid-May, with peak flowering observed during the final week of April in the Sanwara region of Himachal Pradesh, India. The bisexual flowers boast an average diameter of 1.12 cm when fully open [15] and emit a pleasant aroma.

Fruit Morphology

The fruits exhibit a round to oblong shape, measuring 1 to 1.2 cm in diameter and 1.4 to 1.6 cm in length. Each fruit weighs approximately 880 mg, with a volume of 895 microliters. Clusters typically contain 32 to 80 fully ripe black fruits, each containing a single seed measuring 11 mm in length and 8 mm in diameter, comprising 49.4 per cent of the fruit's total weight [15]. These nutrient-dense fruits possess therapeutic properties.

4. Chemistry of Curry Leaves

Curry leaves, renowned for their aromatic and culinary significance, harbor a diverse array of chemical compounds contributing to their distinctive flavor and medicinal properties. The essential oils extracted from these leaves, crucial for their aromatic profile, primarily consist of terpenes and non-terpene constituents. Terpenes, dominant in curry leaf essential oil, form the volatile components responsible for its characteristic aroma, commonly employed in curry flavoring [16]

Studies reveal the presence of various aromatic compounds in fresh curry leaves, showcasing their chemical complexity. Analysis conducted by [16] identified constituents such as β-gurjunene, β-caryophyllene, α-selinene, β-cadinene, β-phellandrene, β-thujene, β-bisabolene, E-β-ocimene, limonene, and β-elemene in both young and mature leaves. Additionally, the prevalence of monoterpenes like β-phellandrene, β-pinene, and α-pinene in North Indian curry leaves, while sesquiterpenes such as β-caryophyllene, α-selinene, and aromadendrene were dominant in South Indian samples. The process of hydro distillation, commonly employed to extract essential oils from fresh curry leaves, yields a volatile oil characterized by its dark yellow hue, spicy aroma, and intense clove-like flavor[17].

Table 1.4. Characteristics of curry leaf volatile oil (Mallavarapu *et al*. (1999)

Constituent	**Content**	
	Young leaves	Old leaves
Caryophyllene (%)	26.3	–
Cadinene (%)	18.2	
Cadinol (%)	12.8	
D-Sabinene (%)	9.2	31.8–44.8
Dipentene (%)	6.8	
D- α -Pinene (%)	5.5	19.0–19.7
β -Pinene (%)		4.2–4.7
D-1- α -Phellandrene (%)	4.6	

β -Phellandrene (%)		6.5–7.9
D- α -Terpinene (%)	3.2	1.3–4.3
△-Terpinene (%)		3.9–7.1
Terpinene-4-ol (%)		5.2–9.9
Lauric acid (%)	2.7	
Palmitic acid (%)	3.4	

Beneficial Pharmacological Properties of Curry Leaves and their Key Active Compounds

Curry leaves are extensively used as a condiment in South Indian and Sri Lankan cuisine. They enhance the flavor of a variety of dishes, including curries, vegetables, fish and meat preparations, chicken and poultry dishes, soups like rasam, lentils, samosas, pickles, buttermilk-based dishes, chutneys, scrambled eggs, and curry powder blends. Additionally, curry leaves are integral to seafood recipes and Madras-style curry powders and pastes. Beyond culinary uses, the leaves are sometimes prepared as a febrifuge in a decoction with bitters. They are also combined with mint in the form of chutney to prevent vomiting. Moreover, curry leaves serve as an anti-periodic, and in Ayurvedic treatments, powdered dry leaves mixed with honey and betel nut juice are often recommended [18]

Antioxidant Activity

Fruits and vegetables are commonly incorporated into daily diets due to their rich antioxidant content, which plays a crucial role in preventing lipid oxidation and neutralizing free radicals. These harmful free radicals and reactive oxygen species are known to cause molecular damage to various biological components such as amino acids, lipids, proteins, and DNA, leading to the onset of several diseases including ageing, cancer, arteriosclerosis, Parkinson’s disease, Alzheimer’s disease, diabetes, and asthma.

Research conducted by Rao[19] revealed that curry leaves contain oleoresin, exhibiting significant radical scavenging activity (RSA) of 83.2%, surpassing water and methanol extracts. Moreover, curry leaves have been found effective as antioxidants in high-fat diets, offering better resistance to oxidation compared to synthetic antioxidants like butylated hydroxy anisole (BHA). The oleoresin derived from curry leaves also serves as a potent skin penetration enhancer for applications in massage, aromatherapy, and transdermal drug delivery.

Studies by [20] have demonstrated the hepatoprotective effects of aqueous curry leaf extracts against APAP-induced liver damage, attributed to the presence of gallic acid.

Furthermore, research by [21] identified carbazole alkaloids, including euchrestine B, bismurrayafoline E, mahanine, mahanimbicine, and mahanimbine, in curry leaves, all exhibiting antioxidative properties. This finding was supported by [21], who reported similar antioxidant activities of carbazole and mahanimbine.

Figure 1. Pharmacological properties of curry leaves

Medicinal Uses

Historically, the leaves of the plant have been utilized for medicinal purposes, addressing ailments such as dysentery, diarrhoea, and vomiting. Extracts from both the bark and leaves are employed to treat skin eruptions and bites from venomous creatures, while fruit juice aids those with kidney problems. Moreover, the crushed bark of the root offers relief from bodily aches when applied topically.

Recent studies have shed light on the medicinal potential of curry leaf extracts. An aqueous extract, for instance, has shown fungitoxicity against fungi causing ringworm and demonstrated a hypoglycemic effect lasting up to 21 hours [22]. This underscores the potential application of volatile oil in various industrial and medical contexts. Importantly, the consumption of powdered leaves has not been found to adversely affect hemoglobin levels. Furthermore, the incorporation of spices like fenugreek and curry leaf into diets has demonstrated beneficial effects on carbohydrate metabolism in experimental and clinical settings [23]. Consequently, curry leaves present themselves as a promising therapeutic option for conditions such as diabetes, hypercholesterolemia, and hepatobiliary issues.

Anticarcinogenic Effect/ Anticancer Activity/ Cytotoxic Activity

Curry leaves antioxidant properties render it a favorable option for both supporting and preventing skin and stomach cancer. A study conducted by Jawaharlal Nehru University in

2003, as published in Nutrition Research, showcased the significant reduction of cancer cell occurrences in stomach and skin tissues upon the introduction of curry leaves. This reduction is attributed to the high concentration of antioxidants present in curry leaves, which not only augment the body's existing antioxidants like superoxide dismutase but also contribute to protective and chemo-preventive mechanisms.

Moreover, the aroma component within curry leaves' essential oil has demonstrated a cancer-suppressing effect across various bodily regions afflicted with cancer cell lines, serving as a shield against carcinogenesis [24] observed a 50% reduction in micronuclei induced by dimethylhydrazine hydrochloride (DMH) through the utilization of curry leaves. Additionally, it is suggested that carbazole alkaloids extracted from Curry leaves can induce apoptosis in human myeloid cancer cells (HL-60).

The incorporation of curry leaf extract into dietary habits holds promise in the prevention of stomach and skin cancers [25]. Further research highlights the cytotoxic effects of various alkaloids, including mahanine, pyrafoline-D, and murrafoline-I, against the KB cell culture system. These effects are echoed by the carbazole alkaloids found in both root bark and stems [26] of curry leaves. Oral administration of freeze-dried leaves of Curry leaves decreased blood glucose levels in normal and diabetic rats by 14.68 percent and 27.96 percent, respectively, according to [27].

Hepatoprotective Effect/ Anti-lipid Peroxidative Activity

Curry leaves harbor a multitude of compounds crucial for bolstering and safeguarding liver health. Researchers have elucidated that the hepatoprotective prowess of curry leaf extract shields liver cells from oxidative stress, chemical insults, and cirrhosis, and impedes the proliferation of cancerous cells within the hepatic milieu. Regular consumption of curry leaves ensues in the fortification of liver functions, facilitating efficacious detoxification pathways and averting the onset of liver malignancies.

In an experimental setting utilizing CCl4-induced hepatotoxic rats, the administration of hydro-ethanolic leaf extracts of Curry leaves at varying dosages (200, 400, and 600 mg/kg body weight) elicited a significant decrease in levels of aminotransferases including alanine aminotransferases, aspartate aminotransferases, total bilirubin, and alkaline phosphatase. Additionally, the treated rats exhibited a dose-dependent escalation in hepatic antioxidant enzymes such as superoxide dismutase, catalase, reduced glutathione, and ascorbic acid, coupled with a concurrent reduction in lipid peroxidation levels. Microscopic evaluations of

liver tissue from treated rats further corroborated these findings, evidencing a notable mitigation of CCl4-induced lesions, thereby underscoring the hepatoprotective potential of Curry leaves [28].

Furthermore, investigations have demonstrated the hepatoprotective efficacy of tannins and carbazole alkaloids present in the aqueous extract of curry leaves. These compounds exhibited significant hepatoprotective effects across all assessed parameters, preserving cellular morphology even under exposure to ethanol, akin to the protective effects conferred by the standard medication L-ornithine-L-aspartate [29].

Antiamnesic and Wound-healing Activity

The antiamnesic potential of curry leaves was explored by [30], who found that an aqueous extract of curry leaves aids in accelerating the healing process by reducing the wound's surface area. A significant reduction in wound area in albino rats treated with the aqueous leaf extract, starting from the 4th day post-injury, compared to the control group using the excision wound model.

Furthermore, the study employed the Elevated Plus Maze model to measure Transfer Latency (TL). They discovered that the memory and learning abilities of aged mice were enhanced by the petroleum ether extract of curry leaves at doses of 300 and 500 mg/kg, as well as by the standard cholinergic drug Piracetam at 400 mg/kg, while the effects of scopolamine were reversed. Moreover, the effects of sodium nitrite were counteracted after 15 days of pretreatment with petroleum ether extract at doses of 300 and 500 mg/kg, with similar efficacy to Piracetam at 400 mg/kg, indicating the potential of curry leaves extract to improve learning capacities under hypoxic conditions.

Additionally, [31] found that dosing aged mice with petroleum ether extract at doses of 300 and 500 mg/kg for 15 days significantly reduced brain cholinesterase activity compared to control groups, with the standard drug Donepezil showing even greater reduction in activity at 0.5 mg/kg.

[32] utilized male albino rats to investigate the wound-healing effects of an ethanolic extract of curry leaves. The results indicated a progressive decrease in wound area over time in all tested groups using the excision wound model. Moreover, rats treated with curry leaves exhibited a significant increase in tensile strength of 12-day-old wounds in the incision model, highlighting the notable wound-healing capacity of curry leaves.

Kidney Protective Activity

Curry leaves' amazing potential to preserve kidneys is becoming more widely known. Curry leaves have been shown in numerous studies to possess innate kidney protective qualities. These benefits are generally ascribed to the wide range of bioactive substances found in curry leaves, which include flavonoids, phenolic compounds, and alkaloids. Strong anti-inflammatory and antioxidant properties are exhibited by these bioactive components, which are essential for protecting renal health from a variety of stresses. Studies reveal that curry leaves can reduce inflammation and oxidative stress in the kidneys, protecting the kidneys' structure and function. Curry leaves have also been demonstrated to lessen kidney damage brought on by nephrotoxic substances such as medications, heavy metals, and environmental pollutants. Curry leaves have a multimodal protective effect by modulating inflammatory pathways, enhancing antioxidant defenses, and scavenging free radicals [33].

Antibacterial Effect

It was found that curry leaves and seed oil possess notable antibacterial and antifungal properties [34]. It also further elucidated that specific compounds found in curry leaves, such as isomahamine and murrayanol, exhibit antibacterial attributes. Additionally, studies demonstrated that when compared to various concentrations of petroleum ether and the standard antibiotic tetracycline (10g/ml), an alcoholic extract at a concentration of 10mg/ml displayed significant antibacterial activity [35].

Moreover, research by [36] showcased the efficacy of curry leaf antioxidant protein in inhibiting the growth of several bacterial strains including E. coli, S. aureus, Bacillus subtilis, Vibrio cholerae, Klebsiella pneumoniae, and Salmonella typhi.

Cardioprotective Activity

Due to their abundance of bioactive components, curry leaves have drawn interest for their possible cardioprotective qualities. Research has indicated that the antioxidants found in curry leaves are essential for protecting cardiovascular health because they fight oxidative stress, which is a major cause of heart disease. By eliminating dangerous free radicals, these antioxidants lower the chance of lipid peroxidation and shield heart tissues from harm. Additionally, it has been discovered that curry leaves have lipid-lowering and anti-inflammatory properties, which strengthen their potential for cardioprotection. Curry leaves may also help lower blood pressure and enhance lipid profiles, which would enhance cardiovascular well-being overall, according to a study. The body of research highlights curry

leaves' potential as a natural supplement for enhancing heart health and lowering the risk of ailments [37].

Antiobesity and Antihyperlipidemic Activities

The ethyl acetate (MKE) and dichloromethane (MKD) extracts of Curry leaves significantly reduced body weight gain, as well as triglyceride (TG) and plasma total cholesterol (TC) levels. These extracts, containing carbazole alkaloids such as Mahanimbine, demonstrated potent antiobesity and antihyperlipidemic properties. Administered orally at a dosage of 30mg/kg/day, Mahanimbine exhibited a remarkable ability to lower TG and TC levels, consequently inhibiting weight gain. These findings underscore the promising pharmacological potential of Mahanimbine in the prevention of obesity, as highlighted by [38].

Antipyretic Activity

The possible antipyretic activity of curry leaves—that is, their capacity to lower fever—has been studied. Research has demonstrated encouraging findings suggesting that some chemicals found in curry leaves can lower fever. These drugs are thought to work by influencing the body's inflammatory response and preventing the release of some chemicals that cause fever. Curry leaves also have a high concentration of antioxidants, which may lessen oxidative stress and scavenge free radicals, thereby contributing to their antipyretic properties. Curry leaves also contain a variety of bioactive substances, including flavonoids, alkaloids, and tannins, which may contribute to their antipyretic properties. Overall, the research points to curry leaves as a potential natural and efficient way to treat fever and other health issues whether added to food or medication formulations[39].

Histopathological Activity

Curry leaves, renowned for their culinary uses, also exhibit notable histopathological properties. Research has elucidated their potential in ameliorating various histopathological conditions. Studies have indicated that compounds present in curry leaves possess anti-inflammatory, antioxidant, and antimicrobial properties, which collectively contribute to their histopathological activity. These properties have been observed to mitigate inflammation, reduce oxidative stress, and inhibit microbial growth, thereby promoting tissue repair and regeneration. Moreover, curry leaves have demonstrated efficacy in alleviating histopathological changes associated with conditions such as skin disorders, gastrointestinal ailments, and liver diseases. Their histopathological effects have been attributed to bioactive

constituents like phenolic compounds, flavonoids, and alkaloids, which exert their therapeutic actions through various molecular pathways. Further research into the histopathological activity of curry leaves holds promise for the development of novel therapeutic interventions targeting a spectrum of histopathological conditions[40].

Antidiarrhoeal activity

Curry leaves, well known for their culinary applications, have several therapeutic benefits as well, one of which is their ability to prevent diarrhoea. Research has demonstrated the effectiveness of curry leaves in treating diarrhoea, a prevalent gastrointestinal disorder. The pharmacological properties of the leaves are attributed to a variety of bioactive substances, including flavonoids, phenolic compounds, and alkaloids. These substances have antibacterial qualities that prevent the growth of bacteria that cause diarrhoea, like Salmonella spp. and Escherichia coli. Curry leaves also have anti-inflammatory qualities that aid in reducing intestinal irritation linked to diarrhoea, therefore relieving symptoms. In addition, the leaves have tannins that help bind intestinal proteins, which makes stools harder and fewer bowel movements occur. Curry leaves have great potential because of these bioactive elements working together. Two bioactive carbazole alkaloids, koenimbine, and kurryam, were found to have considerable inhibitory efficacy against Prostaglandin E2-induced enter polling and castor oil-induced diarrhoea in rats after being extracted from a fractionated n-hexane extract of the seeds of B. koenigii. These chemicals also cause a significant loss in gastrointestinal motility in Wistar rats in the charcoal meal test [41].

Antitrichomonal Activity

Beyond their culinary use, curry leaves have drawn interest for possible medicinal benefits, including antitrichomonal action. Studies reveal that chemicals found in curry leaves have strong antitrichomonal effects, which makes them attractive options for treating infections brought on by the widespread sexually transmitted parasite Trichomonas vaginalis. Alkaloids, flavonoids, and phenolic compounds—bioactive components found in these leaves—have strong antibacterial properties against a variety of diseases, including trichomonads. Curry leaf extracts have been shown in studies to have inhibitory effects on the viability and proliferation of Trichomonas vaginalis, indicating that they may have been used as natural remedies for trichomoniasis. Developing standardized formulations and doing additional research into the precise mechanisms of action are necessary to fully utilize curry leaves' medicinal potential in the fight against trichomonal infections. Carbazole Alkaloids and their derivatives from Curry

leaves have antitrichomonal action against Trichomonas gallinae. The most active compounds were girinimbilol and girinimbine, which had IC50 values of 1.20 and 1.08 mg/mL, respectively. The activity of mahanimbilol and girinimbilol was improved by acetylation to 1.08 and 0.60 mg/mL, respectively [42].

Anthelmintic Activity

Research has shown that curry leaf extracts contain strong anthelmintic qualities that can drive parasitic worms out of the digestive system. The vermifugal effects of bioactive substances such as tannins, flavonoids, and alkaloids are responsible for this activity. Curry leaves' high antioxidant content may also help to counteract the oxidative stress brought on by parasite infestation, which could enhance their anthelmintic action. Curry leaves are a viable natural alternative for treating helminthic diseases because research indicates that their anthelmintic activity may extend to several kinds of intestinal worms. By delving deeper into the mechanisms behind this characteristic, new directions in the development of curry leaf-derived anthelmintic drugs may become apparent, perhaps providing more sustainable and safe treatment alternatives for parasite infections. Aqueous and ethanolic extracts from Curry leaves were tested for anthelmintic activity against Pheretima Posthuma. Both extracts exhibited significant anthelmintic action at a dosage of 100 mg/mL. The alcoholic extract produced significantly greater anthelmintic action than the petroleum ether extract [43].

Antihelminthic action was carried out on the adult Indian earthworm 'Pheretima posithuma’. The organism was chosen because of its similarity to human intestine roundworm parasites. Piperazine citrate was chosen as the standard alcoholic and petroleum ether extracts for the activity. The concentrations of ether and methanolic extracts were 25 mg/ml, 50 mg/ml, and 100 mg/ml. Individual worms were kept under observation to see how long it took for them to become paralyzed and die. Even in normal saline, the worms do not resuscitate. The worms were believed to go into a state of paralysis, and when their motility was lost, along with a fading of their body color, death was assumed. A dose of 100 mg/ml alcoholic extract of plant leaves had a strong anthelminthic effect, whereas petroleum ether had moderate activity [43].

Anti-ulcer Activity

Curry leaf constituents have been shown in studies to have anti-ulcerogenic qualities, which may help prevent and treat gastric ulcers. Numerous bioactive substances found in these leaves, including tannins, flavonoids, and alkaloids, have been demonstrated to have strong

gastroprotective properties. Curry leaf extracts have been shown in studies to reduce the production of stomach acid, increase the secretion of mucin, and reinforce the gastric mucosal barrier, all of which serve to prevent the development of ulcers. Curry leaves also have anti-inflammatory and antioxidant characteristics, which help to prevent ulcer development. Curry leaves may be a safe, all-natural way to treat gastric ulcers and maintain the health of the stomach whether added to food or used in herbal remedies.

Making use of aqueous extract at dosages of 200 and 400 mg/kg, anti-ulcer efficacy was demonstrated. The gastric lesion was significantly inhibited by pylorus ligation-induced ulcer and non-steroidal anti-inflammatory medications. In the pylorus ligation model of gastric juice, the extract reduced stomach volume, ulcerative lesions, and free and total acidity, but raised pH. The findings indicated that the extract has substantial antiulcer activity [44].

Radiation Protection Activity/ Radioprotective and Chemoprotective Activity

Curry leaves have been shown in studies to have substances with antioxidant and free radical scavenging properties, which are essential for protecting cells from the damaging effects of radiation and some toxins. These substances aid in reducing oxidative stress and DNA damage brought on by different chemotherapeutic drugs and ionizing radiation. Curry leaves have also been shown to decrease the expression of pro-inflammatory mediators and increase the activity of detoxifying enzymes, which may further contribute to their protective properties against toxicity brought on by chemicals and radiation. These characteristics highlight curry leaves' potential as a natural supplement to lessen the side effects of radiation and chemotherapy, providing a promising direction for future research into preventive and therapeutic interventions against cancer and other diseases.

The effect of 4 Gy gamma radiation was noticed in adult Swiss albino mice 30 minutes after the final injection of a methanolic extract (100 mg/kg) of Curry for 5 days. The enzyme levels and glutathione were both boosted by the extract, however, radiations drastically lowered all values. By pretreating it with the extract, the radiation-induced lipid peroxidation rate was decreased. The results showed that B. koenigii leaf may protect cellular antioxidants from radiation-induced depletion and has strong antioxidant activity in vitro [45]. In Swiss albino mice, a single dose of 100 mg/kg body weight of the methanolic extract prevented cyclophosphamide-induced chromosomal damage and protected against gamma radiation.

The goal of the study was to see if B. koenigii methanolic extract had chemoprotective and radioprotective properties following irradiation. In vivo, protection against chromosomal

damage caused by radiation RT and cyclophosphamide CP was observed. Gamma Radiation 4Gy caused a considerable rise in the different types of aberrations and per cent aberrant metaphases when compared to the same treated control. Radiation increased chromosomal breakage and fragment chromatids, dicentrics, and rings, among other types of abnormalities. Quantitatively, the methanolic extract pretreatment group shows similar aberrations only in one group. Treatment with a methanolic extract of B. koenigii before radiation, however, resulted in a considerable reduction in the percentage of aberrant metaphases and other types of aberrations. A single dose of methanolic extract 100 mg/kg of B. koenijii can dramatically reduce chromosomal damage induced by cyclophosphamide and irradiation, as well as provide bone marrow protection, according to a leaf extract study[46].

Skin Protection Formula And Anti-ageing

Curry leaves are a fascinating topic of research for skincare and anti-aging formulas because of their amazing diversity of qualities. Curry leaves, which are high in antioxidants such as flavonoids, phenolic compounds, and vitamin C, have strong free-radical scavenging properties that can help shield the skin from damage brought on by oxidative stress. This protection lowers the chance of developing early aging symptoms including wrinkles, fine lines, and age spots by providing shielding from UV radiation, pollution, and other environmental aggressors. Additionally, curry leaves include important nutrients like beta-carotene and amino acids that support collagen synthesis and skin suppleness, giving the appearance of more youthful and supple skin. Curry leaves also have anti-inflammatory qualities that help relieve acne and other sensitive skin issues[44].

Chemo modulatory effect of curry leaves

Curry leaves possess exceptional chemo modulatory characteristics, which have a significant impact on multiple physiological processes in the body. Curry leaves are abundant in bioactive components such as flavonoids, alkaloids, and phenolic compounds, which can influence cellular pathways related to detoxification and antioxidant defense processes. Research has indicated that they possess the ability to alleviate the negative consequences of environmental contaminants, like heavy metals and chemical pollutants, by augmenting the functionality of enzymes that detoxify and eliminate free radicals. Curry leaves may also have a potential future in cancer treatment and chemoprevention since they have been shown to regulate gene expression linked to oxidative stress, inflammation, and carcinogenesis. Curry leaves appear as a useful natural resource for enhancing general health and well-being due to

their complex chemo-modulatory qualities. Sulfhydryl compounds, glutathione-S-transferase, and DT-diaphorase levels were all higher in Swiss albino mice fed a fresh, crude aqueous extract of curry leaf. Antioxidant parameters were found to be higher than normal. The activities of lipid peroxidation and lactate dehydrogenase were reduced [25].

Oral Health/ Effect on Dental Caries

Curry leaves, a staple in various culinary traditions, are also renowned for their beneficial effects on oral health. Rich in antioxidants and antimicrobial compounds, curry leaves help combat oral pathogens, reducing the incidence of dental caries and gum disease. The leaves contain essential oils and alkaloids that inhibit the growth of bacteria such as Streptococcus mutans, a primary contributor to tooth decay. Additionally, the anti-inflammatory properties of curry leaves can alleviate gum inflammation and prevent periodontal diseases. Regular use of curry leaves, whether through direct chewing or incorporating them into the diet, can significantly enhance oral hygiene, reduce bad breath, and promote overall dental health. The holistic benefits of curry leaves make them a valuable natural remedy for maintaining optimal oral health. Curry leaves branches are commonly used to clean teeth as datun and are claimed to strengthen the gums and teeth. Because of its complex leaves, this plant is also highly beautiful. As a result, it can be used as a hedge as well as an ornamental shrub. A food and cake composition containing an active ingredient such as isomahanine, mahanine, murrayanol, and others from Murraya species has been described as having antimicrobial activity against organisms that cause dental caries and periodontal diseases and is safe for the human body, capable of being taken daily with ease even by an infant to prevent dental caries and periodontal diseases [46].

Wound Healing Effect

Curry leaves have strong antibacterial and anti-inflammatory properties that are essential for wound healing. These properties are attributed to the active substances found in curry leaves, such as glycosides, alkaloids, and flavonoids. These substances aid in tissue regeneration, infection prevention, and inflammation reduction. Curry leaf extracts have been found in studies to increase collagen synthesis, which speeds up wound contraction and increases the healing tissue's tensile strength. Curry leaves' antioxidant qualities also help to counteract free radicals at the location of the wound, which further fosters a healing environment. All things considered, using curry leaf extracts in wound care provides a safe, all-natural way to quicken the healing process and enhance the results of wounds. By using an

excision wound model, aqueous extracts of leaves demonstrated a significant reduction in wound size compared to the control group from the 4th day onwards in albino rats. The findings revealed that an aqueous extract of Curry leaves accelerated wound healing by reducing wound surface area [44].

5. Conclusions

Curry leaves, an aromatic shrub native to the Indian subcontinent and a staple in South Asian cuisine, has a rich history in culinary, industrial, and medicinal applications. Their therapeutic potential, supported by scientific studies, is attributed to a high phytochemical content and strong antioxidant properties. Despite their culinary popularity, the industrial potential of curry leaves remains underutilized due to supply volatility and technological challenges. Enhancing cultivation and processing techniques could improve their availability and integration into the global food supply. This review emphasizes the pharmacological attributes, phytochemistry, and medicinal uses of Murraya koenigii, highlighting bioactive compounds such as flavonoids, terpenoids, alkaloids, and polyphenols. These compounds exhibit significant pharmacological activities, including antioxidant, pro-apoptotic, antiangiogenic, antimetastatic, and anticarcinogenic properties, influencing various cell signaling pathways to mitigate neurotoxicity, oxidative stress, neuroinflammation, neuronal loss, and cognitive dysfunctions. However, the limited bioavailability of these polyphenols constrains their efficacy, necessitating future research focused on enhancing their bioavailability and effectiveness through clinical studies.

References

[1] Hamilton, A. C. (2004). Medicinal plants, conservation and livelihoods. Biodiversity and Conservation, 13(8), 1477–1517.

[2] Ayyanar, M. (2013). Traditional Herbal Medicines for Primary Healthcare among Indigenous People in Tamil Nadu, India. Journal of Homeopathy & Ayurvedic Medicine, 2(5).

[3] Hamilton, V. (2018). The Encyclopedia of Herbs and Spices. Reference Reviews, 32(7/8), 31.

[4] Ahluwalia, V., Sisodia, R., Walia, S., Sati, O. P., Kumar, J., & Kundu, A. (2013). Chemical analysis of essential oils of Eupatorium adenophorum and their antimicrobial, antioxidant and phytotoxic properties. Journal of Pest Science, 87(2), 341–349.

[5] 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.

[6] Balakrishnan, R., Vijayraja, D., Jo, S., Ganesan, P., Su-Kim, I., & Choi, D. (2020). Medicinal Profile, Phytochemistry, and Pharmacological Activities of Murraya koenigii and its Primary Bioactive Compounds. Antioxidants, 9(2), 101.

[7] Grover, J., Yadav, S., & Vats, V. (2002). Medicinal plants of India with anti-diabetic potential. Journal of Ethnopharmacology, 81(1), 81–100.

[8] Bhale, V. M., Kadam, P. V., & Sutar, N. G. (2018). Traditional and Medicinal Uses of Murraya koenigii (Curry leaf): A Review. International Journal of Pharmacy and Pharmaceutical Sciences, 10(8), 1-7.

[9] Baliga, M. S., Jimmy, R., Thilakchand, K. R., Sunitha, V., Bhat, N. R., & Saldanha, E. (2011). Ocimum sanctum L (Holy Basil or Tulsi) and its phytochemicals in the prevention and treatment of cancer. Nutrition and Cancer, 63(6), 819-826.

[10] Anitha, R., Beema Shafreen, R. M., Mahalakshmi, R., & Gayathri, R. (2020). Phytochemical and pharmacological activities of Murraya koenigii: A review. Journal of Pharmacognosy and Phytochemistry, 9(1), 933-938.

[11] Chelladurai, V., Janakiraman, U., Manavalan, R., & Ponnusamy, A. (2018). Antioxidant and anti-inflammatory activities of aqueous extract of Murraya koenigii L. leaves in rats. Asian Pacific Journal of Tropical Medicine, 11(8), 469-475.

[12] De Angelis, P. M., Stokke, T., Beigi, M., Mjåland, O., & Clausen, O. P. F. (2001). Prognostic significance of recurrent chromosomal aberrations detected by comparative genomic hybridization in sporadic colorectal cancer. International Journal of Colorectal Disease, 16, 38-45.

[13] Reddy, B.M., Dhanpal, C.K. and Lakshmi, B.V.S., 2018. A review on curry leaves (Murraya koenigii): versatile multi-potential medicinal plant. International Journal of Advances in Pharmacy Medicine and Bioallied Sciences, 6(1), pp.31-41.

[14] Chowdhury, B. K., Jha, S., Bhattacharya, P., & Mukherjee, J. (2001). Two New Carbazole Alkaloids from Murraya koenigii. Indian Journal of Chemistry, 40B, 490-494.

[15] Bonde S. D., Nemade L. S., Patel M. R. and Patel A. A.; 2007. Murrayakoenigii (Curry leaf): Ethnobotany, Phytochemistry and Pharmacology-A Review, International Journal of Pharmaceutical and Phytopharmacological Research , 4(5) : 45-54.

[16] MacLeod, A.J. and Pieris, N.M., 1982. Analysis of the volatile essential oils of Murraya koenigii and Pandanus latifolius. Phytochemistry, 21(7), pp.1653-1657.

[17] Raina, V.K., Lal, R.K., Tripathi, S., Khan, M., Syamasundar, K.V. and Srivastava, S.K., 2002. Essential oil composition of genetically diverse stocks of Murraya koenigii from India. Flavour and fragrance journal, 17(2), pp.144-146.

[18] Khedkar, R.D., 2015. Curry leaf (Murraya koenigii L. Spreng) as a functional food.

[19] Rao, L.J.M., Ramalakshmi, K., Borse, B.B. and Raghavan, B., 2007. Antioxidant and radical-scavenging carbazole alkaloids from the oleoresin of curry leaf (Murraya koenigii Spreng.). Food Chemistry, 100(2), pp.742-747.

[20] Ho, W.Y., Beh, B.K., Lim, K.L., Mohamad, N.E., Yusof, H.M., Ky, H., Tan, S.W., Jamaluddin, A., Long, K., Lim, C.L. and Alitheen, N.B., 2015. Antioxidant and hepatoprotective effects of the food seasoning curry leaves Murraya koenigii (L.) Spreng.(Rutaceae). RSC advances, 5(122), pp.100589-100597.

[21] Ramsewak, R.S., Nair, M.G., Strasburg, G.M., DeWitt, D.L. and Nitiss, J.L., 1999. Biologically active carbazole alkaloids from Murraya k oenigii. Journal of agricultural and food chemistry, 47(2), pp.444-447.

[22] Tachibana, Y., Kikuzaki, H., Lajis, N.H. and Nakatani, N., 2001. Antioxidative activity of carbazoles from Murraya koenigii leaves. Journal of agricultural and food chemistry, 49(11), pp.5589-5594.

[23] Khan, B.A., Abraham, A.N.N.I.E. and Leelamma, S., 1996. Role of Murraya koenigii (curry leaf) and Brassica juncea (Mustard) in lipid peroxidation. Indian Journal of Physiology and Pharmacology, 40, pp.155-158.

[24] Iyer, U.M. and Mani, U.V., 1990. Studies on the effect of curry leaves supplementation (Murraya koenigi) on lipid profile, glycated proteins and amino acids in non-insulin-dependent diabetic patients. Plant Foods for Human Nutrition, 40, pp.275-282.

[25] Rajendran MP, Pallaiyan BB, Selvaraj N. Chemical composition, antibacterial and antioxidant profile of essential oil from Murraya koenigii (L.) leaves. Avicenna J Phytomed. 2014 May;4(3):200-14. PMID: 25050318; PMCID: PMC4104627.

[26] Dasgupta, T., Rao, A. R., & Yadava, P. K. (2003). Chemomodulatory action of curry leaf (Murraya koenigii) extract on hepatic and extrahepatic xenobiotic metabolising enzymes, antioxidant levels, lipid peroxidation, skin and forestomach papillomagenesis. Nutrition Research, 23(10), 1427-1446.

[27] Ito, C., Itoigawa, M., Nakao, K., Murata, T., Tsuboi, M., Kaneda, N., & Furukawa, H. (2006). Induction of apoptosis by carbazole alkaloids isolated from Murraya koenigii. Phytomedicine, 13(5), 359-365.Association of Official Analytical Chemists. (1990). *Official method of analysis* (15th ed). Washington, DC: Author.

[28] CHATTERJI, S., SINGH, R.K., SHUKLA, S., YADAV, D.K. and WATAL, G., 2010. Murraya koenigii-An Evidence Based Study. International Journal of Pharma and Bio Sciences, 1, p.2.

[29] 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, 50(2), 310-314.

[30] Sathaye, S., Bagul, Y., Gupta, S., Kaur, H. and Redkar, R., 2011. Hepatoprotective effects of aqueous leaf extract and crude isolates of Murraya koenigii against in vitro ethanol-induced hepatotoxicity model. Experimental and Toxicologic Pathology, 63(6), pp.587-591.

[31] Vasudevan, M. and Parle, M., 2009. Antiamnesic potential of Murraya koenigii leaves. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives, 23(3), pp.308-316.

[32] Tembhurne, S.V. and Sakarkar, D.M., 2010. Protective effect of Murraya koenigii (L) leaves extract in streptozotocin induced diabetics rats involving possible antioxidant mechanism. J Med Plant Res, 4(22), pp.2418-2423.

[33] Handral, H.K., Pandith, A. and Shruthi, S.D., 2012. A review on Murraya koenigii: multipotential medicinal plant. Asian Journal of pharmaceutical and clinical research, 5(4), pp.5-14.

[34] Yankuzo, H., Ahmed, Q.U., Santosa, R.I., Akter, S.F.U. and 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), pp.88-94.

[35] Gautam M.P. Purohit R.M (1974). Antimicrobial activity of the essential oil of leaves of Murraya koenigii (Linn) Spreng (Indian curry leaf) Indian J. Pharm. 36(1) 11-12.

[36] Thakare RP (1980) Studies on the antibacterial activity of some plant extracts. Indian Drugs 17(5):148

[37] Ningappa, M.B., Dhananjaya, B.L., Dinesha, R., Harsha, R. and Srinivas, L., 2010. Potent antibacterial property of APC protein from curry leaves (Murraya koenigii L.). Food chemistry, 118(3), pp.747-750.

[38] Gopal R, Ambiha R, Sivasubramanian N, Bhupendrabhai PV, Itishaben Girishbhai SI, Govindbhai SN, Narendrabhai SD, Jigneshkumar SN, Rameshbhai VA. Effect of curry leaves in lowering blood pressure among hypertensive Indian patients. Bioinformation. 2023 Oct 31;19(10):1020-1024.

[39] Birari, R., Javia, V., & Bhutani, K. K. (2010). Antiobesity and lipid lowering effects of Murraya koenigii (L.) Spreng leaves extracts and mahanimbine on high fat diet induced obese rats. Fitoterapia, 81(8), 1129-1133.

[40] Khan, B.A., Abraham, A.N.N.I.E. and Leelamma, S., 1996. Role of Murraya koenigii (curry leaf) and Brassica juncea (Mustard) in lipid peroxidation. Indian Journal of Physiology and Pharmacology, 40, pp.155-158.

[41] Patel Vishal, R., Patel Madhavi, G. and Patel Rakesh, K., 2009. Anti-pyretic activity of the ethanolic extract of the powdered leaves of Murraya Koenigii (L.) Spreng. Journal of Pharmacy Research, 2(4).

[42] Mandal, S., Nayak, A., Kar, M., Banerjee, S.K., Das, A., Upadhyay, S.N., Singh, R.K., Banerji, A. and Banerji, J., 2010. Antidiarrhoeal activity of carbazole alkaloids from Murraya koenigii Spreng (Rutaceae) seeds. Fitoterapia, 81(1), pp.72-74.

[43] Adebajo, A. C., Olayiwola, G., Verspohl, J. E., Iwalewa, E. O., Omisore, N. O. A., Bergenthal, D., Kumar, V., & Adesina, S. K. (2005). Evaluation of the Ethnomedical Claims of Murraya koenigii. Pharmaceutical Biology, 42(8), 610-620.

[44] Khuntia TK, Panda DS. Evaluation of antibacterial, antifungal and anthelmintic activity of Murraya koenigii Spreng. Pharma Sci Monit 2011; 2(2):105-110.

[45] Patidar DK. Anti-ulcer activity of aqueous extract of Murraya koenigii in albino rats. International Journal of Pharma and Bio Sciences, 2011; 2(1):524-529.

[46] Deepa I, Devi PU. Radio protective activity of Murraya koenigii (L.) on cellular antioxidants in Swiss albino mice. Journal of Pharmacy Research. 2009; 2(3):495-501.

[47] Inahata Keishiro, Nakasugi Toru Matsumura Shinichi, Nakahara Satoe, (Inahata Koryo Co. Ltd. Japan), Foods Containing Murraya Extract For Prevention And Control Of Bad Breath Jpn. Kokai Tokkyo Koho JP 09, 238, 648 (97).