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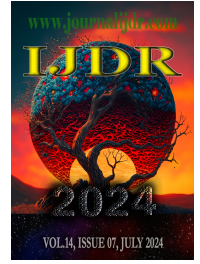
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RESEARCH ARTICLE

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ORIGIN, DISTRIBUTION, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS AND CYTOGENETICS, GENETIC DIVERSITY AND BREEDING OF CURRY LEAF (*Murraya koenigii* (L.) Spreng.)

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ABSTRACT

Drying Curry leaf belongs to the Family Rutaceae, Genus *Begera* and Species *Begera koenigii* (Wikipedia, 2024). The botanical name is **Begera koenigii**, but was once classed as **Murraya koenigii**. Curry leaf belongs to the Family Rutaceae, Genus **Murraya** and Species **Murraya koenigii**. **Other names of** curry leaf tree are curry plant, sweet neem, meethi neem, kadhi patta. **Local names in other Indian languages are** Karepaku (Andhra Pradesh), Narasingha (Assam); Barsanga, Kartaphulli (Bengal); Gorenimb (Gujrat); Mitha Neem (Himachal Pradesh); Kathnim, Mitha Neem, Kurry Patta (Hindi); Karibeva (Karnataka); Kariveppilei (Kerala); Gandhela, Gandla, Gani (Kumaon); Bhursanga (Orissa); Mahanimb (Sanskrit); Karivempu (Tamilnadu). The word "curry" is borrowed from the Tamil word *kari*, literally "blackened", the name of the plant associated with the perceived blackness of the tree's leaves. The records of the leaves being utilized are found in Tamil literature dating back to the 1st and 4th centuries CE. Britain had spice trades with the ancient Tamil region. It was introduced to England in the late 16th century. The former generic name, *Murraya*, derives from Johan Andreas Murray (1740–1791), who studied botany under Carl Linnaeus and became a professor of medicine with an interest in medicinal plants at the University of Göttingen, Germany. The specific name, *koenigii*, derives from the last name of botanist Johann Gerhard König. The curry tree is also called *curry leaf tree* or *curry bush*, among numerous local names, depending on the country. Throughout the rich tapestry of Indian history, the significance of curry leaves has been deeply interwoven into the cultural and culinary traditions of the subcontinent. A testament to their revered status, curry leaves have been celebrated in ancient Indian texts, where they are extolled for their aromatic essence and esteemed for their medicinal properties. References to curry leaves can be found in the ancient Ayurvedic texts, where they are hailed as an essential ingredient in various medicinal concoctions and revered for their potent healing properties. The revered status of curry leaves in ancient Indian texts underscores their enduring cultural significance and their integral role in traditional Indian cuisine and holistic health practices. Curry leaves, an inevitable part of spicing up dishes are not a part of mere garnishing. They are rich in medicinal, nutraceutical properties and have even cosmetic uses. But from the age old days it is customary to pick up curry leaves from dishes and throw it out first before even tasting it. Indian cuisine experts, especially in South India made it a habit to include curry leaves in our daily diet. More than adding to the multi-hued look and spicy taste, there was definitely some other reason why the wise Indian ladies included curry leaf a necessary ingredient in all our dishes. Curry leaves are a popular leaf-spice used in very small quantities for their distinct aroma due to the presence of volatile oil and their ability to improve digestion. "Let food be your medicine and let medicine be your food." Herbal and natural products of folk medicine have been used for centuries in every culture throughout the world. Scientists and medical professionals have shown increased interest in this field as they recognize the true health benefits of these remedies. The important advantages claimed for therapeutic uses of medicinal plants in various ailments are their safety besides being economical, effective and their easy availability. Curry leaf is an important leafy vegetable. Its leaves are widely used in Indian cookery for flavouring foodstuffs. The leaves have a slightly pungent, bitter and feebly acidic taste, and they retain their flavour and other qualities even after drying. Curry leaf is also used in many of the Indian ayurvedic and unani prescriptions. Origin, Taxonomy, Botanical Description, Genetic Diversity, Breeding of Curry Leaf are discussed.

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INTRODUCTION

Curry leaf belongs to the Family Rutaceae, Genus *Begera* and Species *Begera koenigii* (Wikipedia, 2024). The botanical name is *Begera koenigii*, but was once classed as *Murraya koenigii* (Grant, 2023). Curry leaf belongs to the Family Rutaceae, Genus *Murraya* and Species *Murraya koenigii* (Singha et al., 2014; Kumari, 2018; Ch'ng, 2020). Other names of curry leaf tree are curry plant, sweet neem, meethi neem, kadhi patta (SGPL, 2021; Suyash, 2024). Local names in other Indian languages are Karepaku (Andhra Pradesh), Narasingha (Assam); Barsanga, Kartaphulli (Bengal); Gorenimb (Gujrat); Mitha Neem (Himachal Pradesh); Kathnim, Mitha Neem, Kurry Patta (Hindi); Karibeve (Karnataka); Kariveppilei (Kerala); Gandhela, Gandla, Gani (Kumaon); Bhursanga (Orissa); Mahanimb (Sanskrit); Karivempu (Tamilnadu) (Ch'ng, 2020). The word "curry" is borrowed from the Tamil word *kari*, literally "blackened", the name of the plant associated with the perceived blackness of the tree's leaves. The records of the leaves being utilized are found in Tamil literature dating back to the 1st and 4th centuries CE. Britain had spice trades with the ancient Tamil region. It was introduced to England in the late 16th century. The former generic name, *Murraya*, derives from Johan Andreas Murray (1740–1791), who studied botany under Carl Linnaeus and became a professor of medicine with an interest in medicinal plants at the University of Göttingen, Germany. The specific name, *koenigii*, derives from the last name of botanist Johann Gerhard König. The curry tree is also called *curry leaf tree* or *curry bush*, among numerous local names, depending on the country (Wikipedia, 2024).

Throughout the rich tapestry of Indian history, the significance of curry leaves has been deeply interwoven into the cultural and culinary traditions of the subcontinent. A testament to their revered status, curry leaves have been celebrated in ancient Indian texts, where they are extolled for their aromatic essence and esteemed for their medicinal properties. References to curry leaves can be found in the ancient Ayurvedic texts, where they are hailed as an essential ingredient in various medicinal concoctions and revered for their potent healing properties. The revered status of curry leaves in ancient Indian texts underscores their enduring cultural significance and their integral role in traditional Indian cuisine and holistic health practices. Further attesting to their cultural importance, curry leaves have been immortalized in ancient Indian scriptures and epics, where they are regarded as a symbol of vitality and rejuvenation. The mention of curry leaves in these ancient texts serves as a poignant reminder of their enduring cultural significance and their intrinsic link to the holistic well-being of individuals. Embedded within these ancient texts is a profound appreciation for the aromatic allure and the therapeutic virtues of curry leaves, which have been cherished for centuries as an indispensable element of Indian culture and tradition. Moreover, the cultural significance of curry leaves is also reflected in the rituals and customs of Indian households, where the tender, aromatic leaves are revered for their auspicious connotations and are often used in traditional ceremonies and religious offerings. With their deep-rooted cultural symbolism, curry leaves have stood the test of time, permeating the cultural fabric of India and leaving an indelible mark on the collective consciousness of its people. This enduring cultural significance underscores the profound reverence and timeless allure of curry leaves in the annals of Indian heritage (Savorysuitcase, 2023a).

Curry leaves, an inevitable part of spicing up dishes are not a part of mere garnishing. They are rich in medicinal, nutraceutical properties and have even cosmetic uses. But from the age old days it is customary to pick up curry leaves from dishes and throw it out first before even tasting it. Indian cuisine experts, especially in South India made it a habit to include curry leaves in our daily diet. More than adding to the multi-hued look and spicy taste, there was definitely some other reason why the wise Indian ladies included curry leaf a necessary ingredient in all our dishes. Though it is customary to remove these deep green leaves from

dishes we are truly unaware of its health benefits (Singh et al., 2014). Curry leaves are a popular leaf-spice used in very small quantities for their distinct aroma due to the presence of volatile oil and their ability to improve digestion. "Let food be your medicine and let medicine be your food." Herbal and natural products of folk medicine have been used for centuries in every culture throughout the world. Scientists and medical professionals have shown increased interest in this field as they recognize the true health benefits of these remedies. The important advantages claimed for therapeutic uses of medicinal plants in various ailments are their safety besides being economical, effective and their easy availability. Curry leaf is an important leafy vegetable. Its leaves are widely used in Indian cookery for flavouring foodstuffs. The leaves have a slightly pungent, bitter and feebly acidic taste, and they retain their flavour and other qualities even after drying. Curry leaf is also used in many of the Indian ayurvedic and unani prescriptions (Singh et al., 2014).

Curry leaf is an important leafy vegetable. Its leaves are widely used in Indian cookery for flavouring foodstuffs. The leaves have a slightly pungent, bitter and feebly acidic taste, and they retain their flavour and other qualities even after drying. Curry leaf is also used in many of the Indian ayurvedic and unani Prescriptions (Singha et al., 2014). The curry leaf tree is native to India, Sri Lanka, Bangladesh and the Andaman Islands. Later spread by Indian migrants, they now grow in other areas of the world where Indian immigrants settled. Widely cultivated, the leaves are particularly associated with South Indian cuisines (Singha et al., 2014). The use of curry leaves as a flavouring for vegetables is described in early Tamil literature dating back to the 1st to 4th centuries AD. Its use is also mentioned a few centuries later in Kannada literature. Curry leaves are still closely associated with South India where the word 'curry' originates from the Tamil 'kari' for spiced sauces. An alternative name for curry leaf throughout India is kari-pattha. Today curry leaves are cultivated in India, Sri Lanka, Southeast Asia, Australia, the Pacific Islands and in Africa as a food flavouring (Singha et al., 2014).

India is rightfully called as the "Botanical garden of the world". It is the land of several medicinal plants and herbs that are traditionally used to cure ailments. *Murraya koenigii*, is one such plant, also called the curry leaf. It belongs to the family Rutaceae. It grows throughout the Indian subcontinent. It has wide culinary use and is one of the main components of formulations in the traditional Ayurvedic system. The ethanobotanical, phytochemical, pharmacological and pharmacognostic characteristics of *Murraya* have been studied in great detail over the past years. Carbazol alkaloids are abundantly present in its stem, leaf and root extracts. These have antidiabetic, anticancer, antimicrobial, antioxidant and several other beneficial properties (Kamat et al., 2015). *Murraya koenigii* (L.) Spreng. (Family- Rutaceae) commonly known as Meetha neem, is an aromatic more or less deciduous shrub or a small tree up to 6 m in height found throughout India up to an altitude of 1500 m and are cultivated for its aromatic leaves. Its family represents more than 150 genera and 1600 species in the World. It abundantly occurs along the outer Himalayas, Assam, Andaman Islands, Maharashtra, Tamil Nadu, Andhra Pradesh and in the forests of Western Ghats in Karnataka. It is cultivated for its aromatic leaves in south East Asia and Australia, Upper and Lower Burma. It is brought from Andhra Pradesh to Rohilkhand region during 19th century for its aromatic leaves which were used in cookery. Now it is growing wildly in roadsides, agriculture fields and fruit orchards (Kumari, 2018). Curry leaves has slightly pungent, bitter and feebly acidic taste, and they retain their flavour and other qualities even after drying. Curry leaves are a popular leaf-spice and used in very small quantities for their distinct aroma due to the presence of volatile oil and their ability to improve digestion. Leaves are widely used in Indian cookery for flavouring foodstuffs (Kumari, 2018). Furthermore, it has Vitamin A, Vitamin B, Vitamin C, Vitamin B₂, Calcium and iron in plenty. Its nutritional value benefits both the young and the old alike. Women who suffer from calcium deficiency, osteoporosis etc. can find an ideal natural calcium supplement in curry leaves. In traditional system of medicine, it is used as antiemetic, antidiarrheal, dysentery, febrifuge, blood purifier, tonic,

stomachic, antipyretic, antidiabetic, antiobesity, flavouring agent in curries and chutneys. The oil is used externally for bruises, eruption, in soap and perfume industry (Kumari, 2018).

Curry leaf is a perennial leafy vegetable with numerous uses and benefits. It is an integral part of Indian Cuisine. Several medicinal uses are known for this crop. Essential oils and other bio-active chemicals in curry leaf have several industrial applications. Constant domestic and international demands have encouraged the farmers to cultivate curry leaf as sole crop under high density planting. Low input costs, three harvests per year, low post harvest losses; perennial nature with more than 10 years of plantation viability makes curry leaf a best alternative profitable crop for climate resilient agriculture to small and marginal farmers (Raghu *et al.*, 2020c). Curry leaf is an aromatic, semi-evergreen perennial leafy vegetable distributed widely in tropical and sub-tropical regions of the world. It is used for several culinary, nutraceutical, medicinal, therapeutic and industrial purposes owing to the presence of wide range of bio-active and aromatic compounds. Sabinene, Pinene, Cadinol, Caryophyllene and Cadinene are the major compounds responsible for characteristic intense flavour. Monoterpenoids and their oxygenated derivatives are the chief chemical constituents present in essential oil of curry leaf. Carbazole alkaloids having anti-cancerous, antidiabetic and antioxidant properties are the bio-active compounds present abundantly in curry leaf. The crude extract from different parts of curry leaf is an important ingredient in Indian systems of medicine like Ayurveda, Siddha and Unani. The distill extraction of aromatic and volatile oils from curry leaf plant has applications in several cosmetic, perfumeries, soap and food processing industries (Raghu *et al.*, 2020c). Curry leaf is an indispensable part of India systems of food preparation. It is a cheap and rich source of nutrients like calcium (Ca), vitamin A, amino acids and dietary fiber. Other elements present in trace amounts like iron (Fe) and Magnesium (Mg) are also a valuable sources of nutrients to daily consumers (Raghu *et al.*, 2020c). Curry leaf plant is commonly seen in every kitchen garden in South India. However, in recent years, the constant demand in export and local market has encouraged several small and marginal farmers to take up curry leaf cultivation on commercial scale in many districts of Southern India (Raghu *et al.*, 2020c). Curry leaf is a perennial leafy vegetable with multiple uses and benefits. It is used as fresh leaves, dried leaves, dried powder and processed powder with other spices. The shelf life of curry leaf can be enhanced by reducing the leaf moisture level under shade or sun drying. The fresh leaves are integral part of curries, chutny, sambar and other food preparations in Southern India. It not only adds flavor to food but also enhance taste and palatability (Raghu *et al.*, 2020c). Nutritional composition of the food with respect to Ca, vitamin A, amino acids, digestible fiber and other microelements is improved due to curry leaves. Regular use of curry leaves is known to reduce blood sugar level. Several antioxidants, anti-diabetic, anti-cancerous properties present in curry leaves will aid to better functioning of kidney, heart, liver and other vital organs and thus, is regarded as functional food for the man (Raghu *et al.*, 2020c). Curry leaf makes an important part of Ayurveda and other traditional medicinal systems. The ethnobotanical use of curry leaf for medicinal purposes is known since centuries. The crude extracts from different parts of the curry leaf plant is used to treat several diseases and disorders such as piles, influenza, dropsy, itching, bronchial eruptions, fever, asthma, body aches, diarrhoea, kidney pains and vomiting. The green leaves are eaten raw to cure dysentery. The pulped bark and root of curry leaf are externally applied to cure eruptions, fresh cuts and bites of poisonous animals. Besides, essential oil extracted on steam distillation has applications in several industries such as soap, perfumeries, pharmaceutical, nutraceutical and other functional food industries (Raghu *et al.*, 2020c). Owing to its growing demands in both domestic and international markets, the curry leaf cultivation as a commercial leafy vegetable has made its way into several districts of Karnataka, Tamil Nadu, Andhra Pradesh, Telangana and Kerala. India is regularly exporting fresh and dried leaves to Gulf and European countries and earning a considerable amount of foreign returns. The fresh leaves are sold as leafy vegetable in local markets all round the year. This has encouraged many small and marginal

farmers to cultivate curry leaf as a sole crop. Besides, low input demand, low post harvest losses and access to local markets has ensured assured income to the growers throughout the year. Curry leaf is perennial crop, a well maintained plantation can last more than 10 years, which provides continuous income to the farmers (Raghu *et al.*, 2020c).

Curry leaf is an aromatic, tropical and sub-tropical plant with several culinary, nutraceutical, medicinal, therapeutic and industrial values. It is an important and indispensable part of Indian cuisine. The ethnobotanical use of curry leaf for medicinal purposes is known since centuries. Carbazole alkaloids present abundantly in curry leaves have anticancer, anti-diabetic and anti-oxidant properties. The essential oils extracted from curry leaf plant have several industrial applications in the manufacturing of soaps, perfumes, cosmetics, food processing and many others. As curry leaf is a rich source of bio-available calcium and other essential nutrients, it makes an important component of Indian diet and imparts several direct and indirect health benefits to its consumers. As curry leaf is a perennial leafy vegetable, it provides assured income to small and marginal farmers if cultivated on commercial scale and earns considerable amount of foreign returns through export particularly to Gulf and European Unions (Raghu, 2020d). However, understanding the extent of variability, distribution pattern and identification of germplasm rich regions are the prerequisites in any crop improvement program. Furthermore, accelerated use and augmentation of available PGR, identification of trait specific genotypes, mapping and introgression of economically important gene(s)/QTLs (Quantitative Trait Loci) into well adapted and elite genetic background are sign of more efficient and rapid genetic improvement program in any crop species and so with the curry leaf. Moreover, efficient breeding programmes should backup with detailed survey and frequent collaborative germplasm exploration trips to cover wide range of variability, followed by regular exchange and characterization of germplasm between the breeders (Raghu, 2020d).

Curry leaf is a different species from what is commonly referred to as the ornamental curry plant, *Helichrysum italicum*, and neither of these is used in making the spice blend known as curry powder, a British invention that contains no "curry" whatsoever (Lofgren, 2021). The curry leaf plant – also called curry leaf tree, sweet neem, kadi patta, or curry tree – hails from India and is a member of the citrus or rue family, Rutaceae. It can grow up to 20 feet tall at maturity in its native tropics, though it's usually smaller in cultivation. There are multiple varieties available, and three different sizes: regular, dwarf, and miniature. All varieties are evergreen (Lofgren, 2021). It has a graceful, open growth pattern that makes it attractive in an ornamental garden. The plant features showy white flowers in early summer, and dark, sweet, shiny fruits that form in July and August. The seeds are poisonous, but the berries are used in Yunani, Ayurvedic, and homeopathic medicine. The leaves of *M. koenigii* are commonly used in Filipino, Indian, Pakistani, Mexican, Sri Lankan, Cambodian, Malaysian, and Thai cooking. It has long been valued in its native region not only for its citrus-like flavor, but also for its medicinal value. These days, it's cultivated commercially in Sri Lanka and other parts of southeast Asia, Australia, and the Pacific Islands (Lofgren, 2021).

It is said to be originated from Tarai a low land region in Uttar Pradesh. Cultivation is practiced in other countries also like Burma, Sri Lanka, China, Australia, and some of the Pacific countries. It is grown mostly throughout India, mainly cultivated in Assam, Bengal, Western Ghats, cochin and skim to Garhwal, and India leads as one of the largest importers, consumers and producers among the Asian countries (Ponraj *et al.*, 2022). Curry leaves are traditionally used in the preparation of food primarily in Indian cuisine they have a very pungent and acidic flavor. They are also used for treating malaise of gastrointestinal problems as it can be used as an alternative to modern expensive drugs (Ponraj *et al.*, 2022). Some of their beneficial utilizations are, can be used as a blood purifier, for treating stomach aches, and for adding flavors to most dishes made in India. The unique flavor and aroma of the leaves are due to the presence of pinene, sabinene, caryophyllene,

cadinol and cadinene. The use of *Murraya koenigii* (L.) Spreng an attributable spice to culinary and pharmacology is due to the chemical constituents like quercetin, catechin, epicatechin, naringin and myricetin present in their essential oils (Ponraj *et al.*, 2022). Leaves of curry leaf plant have 66% water, 6% protein, 19% fiber and other mineral matter. They are rich in calcium, phosphorus, iron and carotene. They also contain oxalates and phytate phosphorous. It grows well with temperatures ranging from 270 - 470 C, soil with a slightly acidic nature having a pH range of 5 to 7 is ideal for cultivation (Ponraj *et al.*, 2022). Curry leaf is mainly propagated through seeds which are found to be poly embryonic in nature. Variability arises from genotype to genotype both morphologically and chemo-typically the cause of such variation may be due to their genetic nature. They are also propagated by root suckers which shows a low success percentage compared to that of the seed propagation method. Seeds are also considered as a recalcitrant type; they lose viability due to excessive drying and temperature below 100 C (Ponraj *et al.*, 2022). With several knowledge in grafting done previously in curry leaf which showed a better compatibility when wild type rootstock was used. It is found that wedge grafting method showed the highest compatibility among the different methods of grafting with the treatment of IBA solution (Ponraj *et al.*, 2022).

Curry leaf is considered an underutilized tree spice cum medicinal plant and is found in most of the south Indian kitchen gardens. Like other major horticultural crops, this underutilized spice not getting attention with respect to its crop improvement. Due to its vast adaptability and distribution to the different soil, agroclimatic condition, and nutraceutical value, there is a scope for searching genotypes for sodic soil, which will be an alternate crop even for the salt affected soil (Vidhya *et al.*, 2022). Curry leaf is botanically as *Murraya koenigii* L. Spreng has a wide distribution throughout India, both in wild and cultivated forms. It is a perennial tree spice cum medicinal plant and is versatile in nature. A number of 'landraces' of this species are widely found in homestead gardens, especially in southern India. They are underutilized and under explored spice crops in terms of efforts towards their genetic improvement and area under cultivation. Generally, genetic resource of any crop plant includes gene pools of both domesticated and wild species. They are the potential resource of useful genes, which could be of immense use for the genetic improvement of crops (Vidhya *et al.*, 2022). In plant breeding program, it is essential to maintain a germplasm collection or have access to new material in the gene pool from which potential attributes may be incorporated into the crop. Evaluating the genetic variation in the germplasm is the first step toward understanding the scope and utility of material in the collection. Information obtained from the analyses of genetic variability and molecular systematics of crop species will allow the breeders to understand better the biogeographical distribution, variability and historical development of the crop germplasm with which they are working, and to facilitate more efficient use of the available variability for the crop (Vidhya *et al.*, 2022). Curry leaf in India has ample genetic variability. Grouping of the curry leaf genotypes and the presence of variation among them indicated the strong scope for breeding programme. In Tamil Nadu, curry leaf is mainly grown in Coimbatore, Erode, Madurai, Salem and Tiruchirappalli districts. The plant is rich in the volatile properties as well as antioxidants and it is utilized in our traditional systems of medicine too. Every household of Indian kitchen were not satisfied without curry leaves. Because they are used for culinary purposes as a condiment (Vidhya *et al.*, 2022). Recent past this high-value low volume crops are gaining prime value in the nutraceutical industries. The growing demand from the emerging segment of nutraceuticals is driving the global consumption of Indian spices. The curry leaf has vast adaptability and distribution to the different soil, agroclimatic condition, and its nutraceutical value, there is a scope for searching genotypes for salt affected soil, which will be an alternate crop even for the salt affected soil. In addition to that curry leaf has natural variability in its growth, yield and biotic stress (Vidhya *et al.*, 2022).

Curry leaf is an aromatic, semi-evergreen perennial leafy vegetable distributed widely in tropical and sub-tropical regions of the world. It is used for several culinary, nutraceutical, medicinal, therapeutic and industrial purposes owing to the presence of wide range of bio-active and aromatic compounds. Sabinene, Pinene, Cadinol, Caryophyllene and Cadinene are the major compounds responsible for characteristic intense flavor. Monoterpenoids and their oxygenated derivatives are the chief chemical constituents present in essential oil of curry leaf. Carbazole alkaloids having anti-cancerous, antidiabetic and antioxidant properties are the bio-active compounds present abundantly in curry leaf (Raghu *et al.*, 2022a). The crude extract from different parts of curry leaf is an important ingredient in Indian systems of medicine like Ayurveda, Siddha and Unani. The distill extraction of aromatic and volatile oils from curry leaf plant has applications in several cosmetic, perfumery, soap and food processing industries (Raghu *et al.*, 2022a). Curry leaf is an indispensable part of India systems of food preparation. It is a cheap and rich source of nutrients like calcium (Ca), vitamin A, amino acids and dietary fiber. Other elements present in trace amounts like Iron (Fe) and Magnesium (Mg) are also a valuable sources of nutrients to daily consumers. Curry leaf plant is commonly seen in every kitchen garden in South India. However, in recent years, the constant demand in export and local market has encouraged several small and marginal farmers to take up curry leaf cultivation on commercial scale in many districts of Southern India. Thus, its genetic improvement and development of suitable production technologies is very essential to ensure sustainable and profitable cultivation of curry leaf in India (Raghu *et al.*, 2022a).

Curry leaf is a popular leafy-spice native to India and is indispensable part of every Indian cuisine consumed across its diverse food culture from north to south and east to west India. It is an aromatic, perennial, pubescent, semi evergreen shrub capable of growing into small tree of 4-6 m height, and adapted to tropical and sub-tropical climates. It is distributed throughout Indian subcontinent except at higher altitude of more than 1650 m and found both under cultivable and wild forms (Raghu, 2020). Further, it was spread to other parts of the world and found in cultivated forms in Burma, Ceylon, China, Australia and Asia-Pacific Islands. It is commonly cultivated as homestead garden plant, particularly in southern parts of India. In recent times, commercial cultivation of curry leaf under high density planting for fresh leaves are seen in several districts of Tamil Nadu, Karnataka, Andhra Pradesh, Telangana and Kerala. Whereas, naturalized forms are found in forests and waste lands with high rainfall and humid conditions (Raghu and Sandeepkumar, 2023). The leaves are fragrant, strongly aromatic, spicy, bitter, slightly acrid, cooling and weakly acidic in taste and thus, used in small quantity as leafy-spice either in sole or processed forms to improve overall flavour and taste of the different food items such as sambar, chutney, curries and etc., It is also used for seasoning the different foodstuffs such as gravy and other vegetables for the delicious flavor and taste. The aromatic leaves retain their original color and flavour even after drying, therefore they are marketed both in fresh and dried forms. There is a constant demand for fresh leaves in local and domestic markets and thus, farmers are getting good price and better returns throughout the year. It has found export value as well; it is exported to Gulf and European countries from India in the fresh and processed forms. Thus, lately, curry leaf gaining a status of alternative commercial cash crop for small and marginal farmers with assured market demand and returns (Raghu and Sandeepkumar, 2023). Genetic diversity helps plant breeders to utilize genetically diverse parents in a breeding program to improve the productivity of varieties of agriculture and horticulture crops. Genetic diversity changes over time owing to several factors. The main factors responsible for changes in genetic diversity are mutation, selection, genetic drift, and gene flow. Over time, natural and artificial selections play a substantial role in the choosing of superior genotypes, which significantly affects the gene and genotypic frequencies of the population (Salgotra and Chauhan, 2023). Curry leaves are a staple in South Indian and Sri Lankan cuisine, prized for their distinctive flavor and aromatic properties. These small, glossy, dark green leaves are an essential component in many traditional dishes, imparting a citrusy, slightly bitter taste that is

characteristic of South Indian cooking (Savorysuitcase, 2023a). The Curry leaf is very integral to the culinary world of South India. Evidence for its usage can be found in Tamil Literature, between the 1st and 4th century CE, and in Kannada Literature, a few centuries later. In fact, the word 'curry' itself owes its origin to the Tamil word **kari** which is a term used for spicy sauces/gravies in the 16th century. Today it's frequently referred to as kari-pattha. It is interesting to note that, during the reign of Richard II in the late 1300s, there is evidence of English cooks preparing curry! (Indiaculture, 2024). A small tree that grows to an approximate size of about 6 metres, the curry leaf plant is known for its rich foliage. It's a tree full of pinnately arranged leaves. A rich, spicy and aromatic scent engulfs you when you walk past a blooming curry leaf tree. Found practically all over India, except the Himalayas, this tree doesn't fare well in strong winds. Its branches tend to bend and break in windy conditions. The curry leaf plant belongs to the citrus family and it produces small fragrant white flowers that become small, black, berry-like fruits. The fruit is edible, but the seed is poisonous and must be removed prior to use. Curry leaves are mostly used fresh – but they can be dried, powdered and stored too. In fact, in the good old days growing a curry leaf plant in the backyard was a must (Indiaculture, 2024). The curry tree is a tropical and sub-tropical tree in the family Rutaceae (the rue family, which includes rue, citrus, and satinwood), native to Asia. The plant is also sometimes called sweet neem. Its leaves, known as *curry leaves*, also referred to as *sweet neem*, are used in many dishes in the Indian subcontinent (Wikipedia, 2024). Curry leaves are native to the Indian subcontinent and are often mixed with *Helichrysum italicum* (which is also called curry plant in confusion). Its leaves are aromatic — sweet and pungent, which releases a mouthwatering fragrance and is used in cooking (Suyash, 2024).

It is an under exploited crop and a popular leaf spice used in very small quantities for their distinct aroma due to the presence of volatile oil and their ability to improve digestion. A crystalline glucoside "ksenigin" present in leaves and "Murayin" in flowers. The leaves have a slightly pungent, bitter and feckly acidic taste, and they retain their flavour and other qualities even after drying. Curry leaf is also used in many of the Indian ayurvedic and Unani prescriptions. It has many industrial values and medicinal uses (Vasanthkumar *et al.*, 2024). Curry leaf gets its name from the fact that the leaves are frequently used to flavour meals when making curries. Its bark, roots, and leaves are said to have carminative, stomachic, and tonic qualities. The antibacterial and antifungal properties of the essential oil are excellent. Curry leaf seeds have certain insecticidal or repellent qualities. Due to its genuine flavour, curry leaf is widely utilised in Sri Lanka and South India (Vasanthkumar *et al.*, 2024). After distillation, fresh curry leaves yield a volatile oil that is yellow in colour and has a strong, spicy smell as well as a pungent, clove-like flavour. The primary reason it is grown is for its fragrant leaves, which are high in vitamins A and C and can help with digestive issues. While the fruit of Murraya contains the alkaloid koenigin, which is harmful to fungi, the root juice can be used to treat kidney pain (Vasanthkumar *et al.*, 2024).

It is extensively scattered throughout India, Burma, Ceylon, China, Pakistan, Australia, and Pacific Islands. It originated in the Terai tract in Uttar Pradesh. *Murraya koenigii* comes in two related species: *M. paniculate*, which is native to Burma, and *M. exotica*, which is an attractive shrub found in India, Ceylon, and Burma. It is grown in the south-western states of India, Sikkim, Assam, Bengal, and Madhya Pradesh. It is grown commercially in sizable portions of Tamil Nadu, Andhra Pradesh, and Karnataka (Dharwad) (Vasanthkumar *et al.*, 2024). Origin, Taxonomy, Botanical Description, Genetic Diversity, Breeding of Curry Leaf are discussed.

ORIGIN AND DISTRIBUTION

Curry leaf trees are naturalised in forests and waste land throughout the Indian subcontinent except in the higher parts of the Himalayas. From the Ravi River in Pakistan its distribution extends eastwards towards Assam in India and Chittagong in Bangladesh, and

southwards to Tamil Nadu in India. The plants were spread to Malaysia, South Africa and Reunion Island with South Asian immigrants (Singh *et al.*, 2014). The curry leaf tree is native to India, Sri Lanka, Bangladesh and the Andaman Islands. Later spread by Indian migrants, they now grow in other areas of the world where Indian immigrants settled. Curry leaf trees are naturalised in forests and waste land throughout the Indian subcontinent except in the higher parts of the Himalayas. From the Ravi River in Pakistan its distribution extends eastwards towards Assam in India and Chittagong in Bangladesh, and southwards to Tamil Nadu in India. The plants were spread to Malaysia, South Africa and Réunion Island with South Asian immigrants. The use of curry leaves as a flavouring for vegetables is described in early Tamil literature dating back to the 1st to 4th centuries AD. Its use is also mentioned a few centuries later in Kannada literature. Curry leaves are still closely associated with South India where the word 'curry' originates from the Tamil 'kari' for spiced sauces. An alternative name for curry leaf throughout India is kari-pattha. Today curry leaves are cultivated in India, Sri Lanka, Southeast Asia, Australia, the Pacific Islands and in Africa as a food flavouring (Singh *et al.*, 2014).

The curry leaf originated from Indian sub-continent including Andaman and Nicobar Islands, Sri Lanka and Bangladesh. Later expanded to different parts of the world by Indian migrants. Presently, it is grown in various tropical and subtropical regions such as, India, Sri Lanka, Bhutan, Nepal, Malaysia, Southern China, Guangdong, Southern Hainan, Southern Yunnan, Laos, Vietnam, Thailand, Mariana Islands, Vanuatu, New Caledonia, Ryuku Islands, Australia and South Africa (Raghu, 2020d). Curry leaf is widely distributed throughout India except in higher altitudes of Himalayas. It is found abundantly in forests and waste lands in natural, wild and cultivated forms up to 1650 m altitude. In southern India, it is found in homestead gardens of every household (Raghu, 2020d). Plant genetic wealth of curry leaf in India Curry leaf plant is originated from India and its adjoining regions of Sri Lanka, Bangladesh and Nepal. Later, it has spread to other parts of the world by Indian migrants. In India, it is distributed throughout its mainland including Andaman and Nicobar Islands, and found naturally in semi-deciduous to evergreen forests with medium to high rainfall. Foot hills of Himalayas in North, continued through Terai region, Sikkim hills, Darjeeling hills and end up in Khasi-Garo hills in far east, reaching far up to Nilgiri and Annamalai hills in South, covering deciduous and semi-deciduous forests in Middle India and Eastern Ghats, including evergreen forests of Western Ghats are the major diversity regions for curry leaf in India (Raghu *et al.*, 2020c). The curry leaf tree is native to India, Sri Lanka, Bangladesh and the Andaman Islands. Curry leaf was later spread by Indian migrants, and they now grow in other areas of the world where Indian immigrants settled. Curry leaf is widely cultivated, and the leaves are particularly associated with South Indian cuisines (Ch'ng, 2020). Curry leaf trees are naturalized in forests and abandoned land throughout the Indian subcontinent except in the higher parts of the Himalayas. From the Ravi River in Pakistan its distribution extends eastwards towards Assam in India and Chittagong in Bangladesh, and southwards to Tamil Nadu in India. The plants spread to Malaysia, South Africa and Reunion Island with South Asian immigrants (Ch'ng, 2020). Native to India, the tree loves full sun and grows best in it. While the plant is in the growing stage, avoid exposing it to the harsh afternoon sun for a longer duration of time. Once established, you don't have to worry much about it (SGPL, 2021).

Curry leaf plant is originated from India and its adjoining regions of Sri Lanka, Bangladesh and Nepal. Later, it has spread to other parts of the world by Indian migrants. In India, it is distributed throughout its mainland including Andaman and Nicobar Islands, and found naturally in semi-deciduous to evergreen forests with medium to high rainfall. Foothills of Himalayas in North, continued through Terai region, Sikkim hills, Darjeeling hills and end up in Khasi-Garo hills in far east, reaching far up to Nilgiri and Annamalai hills in South, covering deciduous and semi-deciduous forests in Middle India and Eastern Ghats, including evergreen forests of Western

Ghats are the major diversity regions for curry leaf in India (Raghu et al., 2022a). The story of curry leaves begins in the lush landscapes of the Indian subcontinent, where these small, aromatic leaves have been an integral part of the region's culinary and medicinal traditions for centuries. Known for their distinct flavor and fragrance, curry leaves are derived from the curry tree, scientifically known as *Murraya koenigii*. This evergreen tree belongs to the Rutaceae family and is native to the Indian subcontinent, particularly in the tropical and subtropical regions of India, Sri Lanka, and other parts of Southeast Asia (Savorysuitcase, 2023a). The tree is native to the Indian subcontinent. Commercial plantations have been established in India, and more recently Australia (Wikipedia, 2024).

History

The use of curry leaves as a flavoring for vegetables is described in early Tamil literature dating back to the 1st to 4th centuries AD. Curry leaves are still closely associated with South India where the word 'curry' originates from the Tamil 'kari' for spiced sauces. An alternative name for curry leaf throughout India is kari-pattha. Today curry leaves are cultivated in India, Sri Lanka, Southeast Asia, Australia, Pacific Islands, and in Africa as a food flavoring (Ch'ng, 2020). The origin of curry leaves can be traced back to the Indian subcontinent, where they have been used in cooking and medicinal practices for thousands of years. Their unique flavor profile and aromatic qualities have made them an integral part of Indian cuisine, and they are often referred to as the "heart and soul" of South Indian cooking. As a result, curry leaves have become deeply ingrained in the cultural and culinary heritage of the region, with a history that reflects the rich tapestry of Indian traditions and customs. Throughout history, curry leaves have been celebrated for their medicinal properties and are believed to have various health benefits, including aiding in digestion, promoting hair growth, and reducing stress. As such, they hold a special place in Ayurvedic medicine and are revered for their therapeutic qualities. Additionally, the aromatic nature of curry leaves has made them a popular ingredient in perfumes and essential oils, further highlighting their versatility and significance in various aspects of Indian culture and society (Savorysuitcase, 2023a). The historical roots of curry leaves can be traced back to ancient Indian civilization, where they have been an integral part of culinary and medicinal practices for centuries. These aromatic leaves hold a significant place in the history of Indian cuisine, with references to their use dating back to ancient texts such as the Charaka Samhita and Sushruta Samhita, which are foundational texts in Ayurveda, the traditional system of medicine in India. The mention of curry leaves in these texts underscores their long-standing presence in Indian culture and their valued role in promoting health and wellbeing. Throughout history, curry leaves have been cultivated and utilized in various regions of India, each contributing to the diverse culinary traditions found across the country. Their cultivation and usage are deeply intertwined with the agricultural practices and regional cuisines of different Indian states, reflecting the rich tapestry of Indian food culture. The historical significance of curry leaves is evident not only in their culinary applications but also in the traditional medicinal practices where they have been recognized for their therapeutic properties. The historical roots of curry leaves are also closely linked to the migration and trade routes that shaped the cultural exchange between India and other regions. As these aromatic leaves gained popularity, they became an essential ingredient in the cuisines of neighboring countries, further highlighting their historical significance beyond the borders of India. The exploration of historical texts, culinary traditions, and trade routes provides a comprehensive understanding of the enduring role of curry leaves in shaping the cultural and gastronomic heritage of India (Savorysuitcase, 2023). As Indian diaspora spread to various parts of the world, they brought with them not just their customs and traditions, but also the flavors and aromas of their native cuisine. This diasporic movement played a significant role in popularizing curry leaves in countries such as Malaysia, Sri Lanka, and the Caribbean, where they found a natural home in the local culinary practices, enriching the flavors of diverse regional dishes. The globalization of Indian cuisine, propelled by the growing interest in international flavor, has further contributed to the

widespread adoption of curry leaves in modern gastronomy. As the culinary world continues to embrace the diversity of flavor, curry leaves have found their way into the kitchens of renowned chefs and home cooks alike, adding a distinctive and aromatic touch to a wide array of dishes. Today, curry leaves have become a staple in the pantries of many households outside of India, particularly in countries with a strong appreciation for bold, aromatic flavor. Their versatility and unique citrusy aroma have made them a sought-after ingredient in fusion cuisine, as chefs experiment with blending traditional Indian flavor with local culinary influences, creating innovative and enticing dishes that reflect the interconnectedness of global gastronomy. The journey of curry leaves from their humble origins to their global presence serves as a testament to the enduring influence of Indian culinary heritage and the universal appeal of its vibrant flavor. As they continue to captivate the palates of people around the world, curry leaves stand as a symbol of the rich tapestry of global culinary traditions, uniting diverse cultures through the shared love of aromatic and flavorful cuisine (Savorysuitcase, 2024b). It is found to be native to South Asia particularly India, Sri Lanka and Bangladesh (Vasanthkumar et al., 2024).

TAXONOMY

Curry leaf belongs to the Family Rutaceae, Genus *Begera* and Species *Begera koenigii* (Wikipedia, 2024). The botanical name is *Begera koenigii*, but was once classed as *Murraya koenigii* (Grant, 2023). Curry leaf belongs to the Family Rutaceae, Genus *Murraya* and Species *Murraya koenigii* (Singha et al., 2014; Kumari, 2018; Ch'ng, 2020). Other names of curry leaf tree are curry plant, sweet neem, meethi neem, kadhi patta (SGPL, 2021; Suyash, 2024). The botanical name of the curry leaves is *M. koenigii*. As literature exposed the species name commemorates the botanist called Johann Konig. The genus *Murray* commemorates Swedish physician and botanist Johann Andreas Murray who died in 1791 (Ch'ng, 2020). The curry leaf plant, scientifically known as *Murraya koenigii*, falls within the classification of the plant kingdom Plantae. It belongs to the Angiosperms, or flowering plants, specifically in the order Sapindales. Within the Sapindales order, the curry leaf plant is part of the Rutaceae family, commonly called the citrus or rue family. *Murraya* is the genus to which the curry leaf plant belongs. The specific epithet "koenigii" honours Johann Gerhard König, a Danish botanist. This aromatic evergreen shrub is native to the Indian subcontinent and is valued for its culinary and medicinal uses. Curry leaf is an important perennial tree vegetable cum spice crop belongs to the family Rutaceae consisting 150 genera and 1600 species (Vasanthkumar et al., 2024).

The word "curry" is borrowed from the Tamil word *kari*, literally "blackened", the name of the plant associated with the perceived blackness of the tree's leaves. The records of the leaves being utilized are found in Tamil literature dating back to the 1st and 4th centuries CE. Britain had spice trades with the ancient Tamil region. It was introduced to England in the late 16th century. The former generic name, *Murraya*, derives from Johan Andreas Murray (1740–1791), who studied botany under Carl Linnaeus and became a professor of medicine with an interest in medicinal plants at the University of Göttingen, Germany. The specific name, *koenigii*, derives from the last name of botanist Johann Gerhard König. The curry tree is also called *curry leaf tree* or *curry bush*, among numerous local names, depending on the country (Wikipedia, 2024). Curry leaves plant comes in three distinct varieties/ morphotypes with their own set of pros and cons – Regular, Dwarf, and Gamthi (SGPL, 2021; Grant, 2023; Suyash, 2024).

- **Regular Curry Tree/ Large, or standard:** It grows up very fast and reaches a height of 6-15 feet and a width of 4-12 feet. The leaves of this plant are commonly found in the grocery stores and the most widely cultivated out of the three available options. Large, or standard, curry trees are the ones that are most commonly cultivated for commercial production. If you're buying curry leaves at the store, they most likely came from a standard plant. Large trees grow fast and have flavorful leaves. They grow

best in Zones 9-12, in gardens where they can be grown outdoors year-round. There are a few cultivars of the standard size that you can find, though most plants that are available from nurseries in the United States are sold under the generic species name *M. koenigii*.

- **Dwarf Variety:** It is an excellent choice for a houseplant or to grow in containers to decorate your patio that could also be placed indoors during winters. The dwarf variety has longer leaves that are slightly lighter in color than those of the full-size plant. These grow to be about 12 to 24 inches tall and 12 inches wide at maturity. These may spread via suckers and in the right conditions they can even become invasive, so container planting or regular pruning of the suckers may be necessary. The dwarf variety may be grown outdoors year-round in Zones 8-11.
- **Gamthi (miniature):** It is even smaller than the dwarf variety and reaches 6-8 inches in height on full maturity. Though it does not spread as quickly but makes up for it by producing the most fragrant leaves of all curry plants. Gamthi varieties grow the slowest and have thick, highly fragrant leaves. If you want a plant to grow in a container indoors that you can also harvest leaves from to use as an herb in your cooking, I'd recommend this one.

Three different morphotypes with respect to color and size of leaves, habitat of the plant, flavor of the plant as, Brown/Gamthi (GM), Regular (RE) and Dwarf (DF), are identified in India. Brown types are most fragrant slowly growing; leaves are small, thick with serrated edges and dark brown in color. Regular types are fastest growing and grow as tree, greater in look, and leaves are exstipulate, bipinnately compound and long having reticulate venation with dark in color and available throughout the country. Dwarf types grow as a shrub with moderate growth, spreading branches and appears as a bush, leaves are light green, look like a regular type but aromaticity of its own. All three morphotypes differ for intensity of flavor. The radical scavenging capacity of methanolic extracts of three morpho-types was in the order of Gamthi > Dwarf > Regular, with IC₅₀ values of 171, 365 and 471 (g/ml), respectively. 6 mg/ml types and 6.01, 4.82 and 3.58 mg/ml of flavonoids were reported in GM, DF and RE, respectively. Further, curry leaves exhibited huge variability with respect to chemical composition of essential oils over locations and seasons (Raghu, 2020d). A huge morphological and chemical diversity is reported in curry leaves. Broadly, curry leaf is classified into three morphological types viz., Brown/Gamthi (GM), Regular (RE) and Dwarf (DF) based on growth habit, color and size of leaves and flavor. Slow growing genotypes with dark brown small and thick leaves having serrated edges are Brown/Gamthi (GM). It is most fragrant type of curry leaf. Whereas, genotypes grow very fast, sometimes turn into small-medium-sized trees and produces exstipulate, bipinnately compound dark leaves with long reticulate venation are referred to as regular type (RE) and this type is available throughout India. Dwarf types (DF) are moderately growing genotypes with spreading branches to form bushy habit and its leaves are light green, exstipulate, bipinnately compound with long reticulate venation and having unique aromaticity. Further, morphotypes vary for anti-oxidant activity in the order of Gamthi, Dwarf, Regular types (Raghu *et al.*, 2022a).

There are three varieties of curry tree (Vasanthkumar *et al.*, 2024):

- Regular-which is a common variety grown everywhere and tallest of all.
- A dwarf variety- which is good for container though less aromatic
- Third variety (gamthi)-which is the highly aromatic and pungent variety in all the three.

BOTANICAL DESCRIPTION

Shrubs or trees, to 4 m tall. Leaves 17-31-foliolate; leaflet blades ovate, 2.5 × 0.5-2 cm, base obtuse to rounded and oblique, margin entire or crenulate. Inflorescence's terminal, paniculate, many flowered. Flowers 5-merous, ellipsoid in bud. Sepals ovate, less than 1 mm. Petals white, oblanceolate to oblong, 5-7 mm. Stamens 10. Stigma capitate. Fruit bluish black, ovoid to oblong, 1-1.5 cm, 1-

or 2-seeded. Seed coat membranous (Saxena and Brahmam 1994). A small spreading shrub, about 2.5 metres high; the main stem, dark green to brownish, with numerous dots on it; its bark can be peeled off longitudinally, exposing the white wood underneath; the girth of the main stem is 16 cm. Leaves, exstipulate, bipinnately compound, 30 cm long, each bearing 24 leaflets, having reticulate venation; leaflets, lanceolate, 4.9 cm long, 1.8 cm broad, having 0.5-cm-long petiole. Flowers, bisexual, white, funnel-shaped, sweetly scented, stalked, complete, ebracteate, regular, actinomorphic, pentamerous, hypogynous, the average diameter of a fully opened flower being 1.12 cm; inflorescence, a terminal cyme, each bearing 60 to 90 flowers; calyx, 5-lobed, persistent, inferior, green; corolla, white, polypetalous, inferior, with 5 petals, lanceolate; length, 5 mm; androecium, polyandrous, inferior, with 10 stamens, dorsifixed, arranged into circles of five each; smaller stamens, 4 mm. long whereas the longer ones, 5 to 6 mm; gynoecium, 5 to 6 mm long; stigma, bright, sticky; style, short; ovary, superior. Fruits, round to oblong, 1.4 to 1.6 cm long, 1 to 1.2 cm in diameter; weight, 880 mg; volume, 895 microlitres; fully ripe fruits, black with a very shining surface; pulp, Wistaria blue 640/2; the number of fruits per cluster varying from 32 to 80. Seed, one in each fruit, 11 mm long, 8 mm in diameter, colour spinach green 0960/3; weight, 445 mg; volume, 460 microlitres (Singh *et al.*, 2014).

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Murraya koenigii (L.) Spreng. is a subtropical tree which known as miracle plant, belongs to family Rutaceae. The main stem is dark green to brownish, with numerous dots on it. The bark can be peeled off longitudinally, exposing the white wood underneath. The girth of the main stem is 16 cm. Leaves are exstipulate, bipinnately compound, 30 cm long, each bearing 24 leaflets, having reticulate venation; leaflets, lanceolate, 4.9 cm long, 1.8 cm broad, having 0.5 cm long petiole. Inflorescence bears 60-90 flowers. They are bisexual, white, funnel-shaped, sweetly scented, stalked, complete, ebracteate, regular, actinomorphic, pentamerous, and hypogynous. The average diameter of a fully opened flower is 1.12 cm. Flowers with calyx 5 lobed, persistent, inferior, green; corolla, white, polypetalous, inferior, with 5 petals, lanceolate, length, 5 mm; androecium, polyandrous, inferior, with 10 stamens, arranged into circles of five each; smaller stamens, 4 mm. long whereas the longer ones, 5-6 mm; gynoecium, 5-6 mm long; stigma, bright, sticky; style, short; ovary, superior. Fruits, round to oblong, 1.4-1.6 cm long, 1-1.2 cm in diameter; weight, 880 mg; volume, 895 microlitres; fully ripe fruits, black with a very shining surface. Seed, one in each fruit, 11 mm long, 8 mm in diameter, colour spinach green to black (Kumari, 2018).

The *M. koenigii* is semi deciduous, unarmed aromatic small spreading shrub or tree with strong woody stem but slender with the stem which is dark green to brownish in color the tree is 4-

8.7m tall, with a trunk up to 81 cm diameter. The diameter of main stem is about 16 cm. The flowers of curry leaves are small, white fragrant and funnel shaped, regular, pentamerous, stalked, complete, ebracteate, hypogynous, persistent, inferior, green, corolla, polypetalous, androecium, polyandrous, lanceolate, stigma, bright, sticky, style, short, ovary, inflorescence, a terminal cyme. The diameter of a flower is 1.12cm in the fully opened form. Each cluster bears approximately 60 to 90 flowers at a time, 5-lobed calyx, with 5 petals having length of 5 mm each. There are 10 stamen in small in size, which is approximately 4 mm. They are dorsifixed, arranged into circles, with long superior gynoecium with size of 5 to 6 mm. Curry tree flowers have a sweet fragrance, bisexual with self-pollinated for produce black berries in small size with shiny appearance containing a large visible seed. Curry leaves are aromatic in nature. The leaves are shiny and smooth with paler undersides. Leaves are pinnate, exstipulate, having reticulate venation and having ovate lanceolate with an oblique base, with 11-21 leaflets, in which each leaflet is 0.79–1.57 inch long and 0.39–0.79 inch broad. Leaflets are short stalked, alternate, gland dotted and having 0.5 cm long petiole. The leaf margins are irregularly serrate. The yield of a bush is approximately 480 g. The stem of *M. koenigii* is brown to dark green in color, with dots on the bark like small node on it. When the bark is peeled off longitudinally, there is a white color wood underneath. The girth of the main stem is 16 cm, 6 meters in height, and 15 to 40 cm in diameter. Fruits of the *M. koenigii* occur in cluster form varies in 32 to 80 in number. The fruits are in the ovoid form and small in size. The fruits are 1 to 1.2cm in the diameter with a length of 1.4 to 1.6 cm. They are purple black in color after ripening and they are edible. The fruit yields 0.76% of a yellow volatile oil. Curry leaf fruit is 11 mm long and weigh about 445 mg fruits. The weight of pulp is 880 mg and the volume is 895 microliters. The seeds of the *M. koenigii* are poisonous in nature and should not be consumed for any purpose (Ch'ng,2020). It is a semi-deciduous, aromatic, pubescent and unarmed shrub or small tree capable of growing up to 6 meter height with slender but strong woody stem.

Later, the woody stem develops into densely crowded shaded crown. The leaves of curry leaf plant are alternate, estipulate, bipinnately compound, glabrous, 15-20 cm long, rarely pubescent at young and gland dotted and extremely strongly aromatic with numerous volatile compounds. The leaflets are alternate and short stalked; ovate to ovate lanceolate in shape with number varies from 9 to 12 or more per leaf. The leaves are slightly pungent, bitter and aciduous in taste. The major chemical compounds responsible for characteristic intense aroma and flavor are sabinene, pinene, cadinol, caryophyllene and cadinene. Monoterpenoids and their oxygenated derivatives are the chief chemical constituents present in essential oil of curry leaf. The essential oils extracted from fresh leaves collected from different parts of Western Ghats, India contains significant amount of monoterpene hydrocarbons such as sabinene (6.90-40.59%), β -phellandrene (1.39-45.89%) and α -pinene (1.93-63.66%), and a sesquiterpene hydrocarbon β -caryophyllene (6.68-18.46%) (Raghu, 2020d). Curry leaf plants are members of the family Rutaceae, which encompasses plants such as citrus and the cork tree. The plant is known as "sweet neem" in its indigenous range and also bears numerous Indian names. The little tree or bush may grow up to 15 feet (4.6 m) high with a spread of 12 feet (3.6 m). The tree produces vertically peeling bark of greenish brown, which when removed reveals bright white wood. The leaves are compound, with delicate leaflets. Curry leaf plant flowers are small, white, deeply scented, and funnel shaped. They appear from April to May. After bloom, roundish to elliptical berries appear, deeply black and glossy when ripe. Fruits arrive in heavy clusters of 30-80 from July to August. The fruit is edible, but the seed is poisonous and must be removed prior to use. The seeds are very large and green, leaving little edible pulp. However, the pulp is often used in dessert preparations. They are high in Vitamin C and other nutrients. The foliage is the real standout -- it's arranged alternately on the stem and pinnate and is comprised of many leaflets. The pungent scent is spicy and heady, and best when the leaves are fresh (Grant, 2023). It is a small tree, growing 4–6 metres tall, with a trunk up to 40 cm in diameter. The aromatic leaves are pinnate, with 11–21 leaflets, each leaflet 2–4 cm long and 1–2 cm broad.

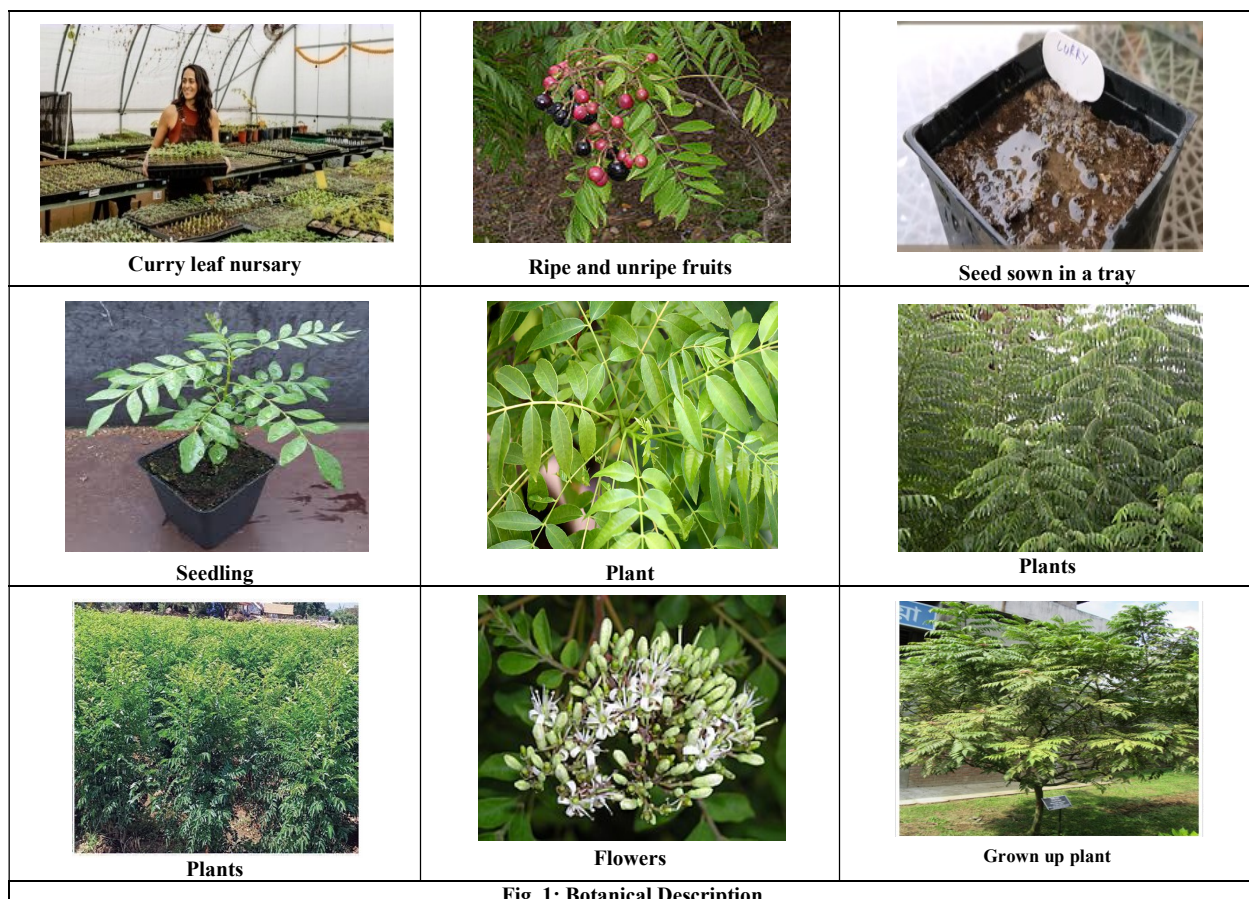


Fig. 1: Botanical Description

The plant produces small white flowers which can self-pollinate to produce small shiny-black drupes containing a single, large viable seed. The berry pulp is edible, with a sweet flavour (Wikipedia, 2024). It is an aromatic tree growing to a height of 6m. Its stem is slender and strong. The branches are covered with dark-grey bark. The aromatic leaves are pinnate, with 11–21 leaflets, each leaflet 2–4 cm long and 1–2 cm broad. The plant produces small white flowers which can self-pollinate to produce small shiny-black drupes containing a single, large viable seed. The berry pulp is edible, with a sweet flavour (Vasanthkumar *et al.*, 2024). The curry tree is a tropical to sub-tropical tree in the family Rutaceae and is native to Asia. It is a small bush or tree that only grows 4 m to just under 6 m in height and has a bi-pinnate leaf pattern. The Curry Leaf produces small, fragrant, white flowers in summer, which then produce small, berry like fruit with a single hard stone in the centre, the seed. As the berries mature, they become dark purple in colour and taste sweet when ripe, but not really nice enough to be eaten as a fruit. Please be aware that the seed is poisonous and must be removed prior to use (Jekkas, 2024). Botanical description of curryn leaf is given in Fig. 1.

Pollination

Curry leaf is highly self-pollinated crop. The flowers are bisexual, produced many in a terminal pedunculate inflorescence arranged compact, corymbiform and cymose panicle. The bisexual flowers are very small measuring about a cm length, white and fragrant. The flowers contain five deeply cleft and pubescent calyx, five free and spreading petals, ten freely and alternatively arranged short and long, linear and subulate stamens with small and short anthers. The style is thick, elongated, cylindrical and articulate with capitate or grooved stigma. The flowering occurs mainly in the middle of April to middle of May reaching its peak in last week of April. The curry leaf plant bears small berries, measuring 1-2 cm diameter with thin pericarp and mucilaginous pulp enclosing 1 or 2 seeds. The fruiting starts from middle of July and continue up to end of August. Upon ripening, the fruits turn red and ultimately black and seeds are non endospermic with membranous and glabrous testa bearing small embryo. Propagation occurs either through seeds or rooted suckers (Raghu, 2020d). Pollination is the process by which pollen from the male part of a flower (the stamen) is transferred to the female part (the pistil). This transfer is essential for fertilization and the production of seeds, fruits, and vegetables. In the case of curry leaf plants, pollination is necessary for the plant to produce fruit. Curry leaf plants are self-pollinating, which means that they have both male and female reproductive organs in each flower. However, natural pollination may not always occur due to various factors, including lack of insects or wind. If your plant is not producing fruit, it may be because of poor pollination. Hand pollination is an effective way to ensure that your curry leaf plant produces fruit (Livetoplant, 2023).

GENETIC DIVERSITY

It is true diploid with chromosome number, $2n=18$ ($x=9$). It is found in various tropical and subtropical regions of the world (Raghu, 2020d). *Murraya koenigii* (L.) Spreng. (Rutaceae), is an aromatic plant and much valued for its flavor, nutritive and medicinal properties. In this study, three DNA fingerprinting methods viz., random amplification of polymorphic DNA (RAPD), directed amplification of minisatellite DNA (DAMD), and inter-simple sequence repeat (ISSR), were used to unravel the genetic variability and relationships across 92 wild and cultivated *M. koenigii* accessions. A total of 310, 102, and 184, DNA fragments were amplified using 20 RAPD, 5 DAMD, and 13 ISSR primers, revealing 95.80, 96.07, and 96.73% polymorphism, respectively, across all accessions. The average polymorphic information content value obtained with RAPD, DAMD, and ISSR markers was 0.244, 0.250, and 0.281, respectively. The UPGMA tree, based on Jaccard's similarity coefficient generated from the cumulative (RAPD, DAMD, and ISSR) band data showed two distinct clusters, clearly separating wild and cultivated accessions in the dendrogram. Percentage polymorphism, gene diversity (H), and Shannon information index (I) estimates were higher in cultivated accessions compared to wild

accessions. The overall high level of polymorphism and varied range of genetic distances revealed a wide genetic base in *M. koenigii* accessions. The study suggests that RAPD, DAMD, and ISSR markers are highly useful to unravel the genetic variability in wild and cultivated accessions of *M. koenigii* (Verma and Rana, 2013).

Studies on variability and association of characters in curry leaf genotypes were carried out with eight genotypes collected around Coimbatore district at HC&RI, Coimbatore during 2017-2019. Significant variability was observed for all the characters recorded in the curry leaf genotypes. Among the characters studied length of the matured shoot (118.90 and 114.95), plant height (66.27 and 51.41) and the number of compound leaf per matured shoot (18.97 and 17.24) recorded the highest phenotypic and genotypic variances respectively. Highest Phenotypic coefficient of variation and genotypic coefficient of variation was recorded for weight of the matured shoot (18.80 and 18.74), the number of matured shoot (15.13 and 14.98), the number of compound leaf per matured shoot (10.74 and 10.49) and fresh leaf yield /plant (10.63 and 10.40) Less variation was noticed between Phenotypic co-efficient of variation and Genotypic co-efficient of variation, which indicates environmental influence was low for all the characters. Number of matured shoots (98.09 and 30.57), Length of matured shoots (96.68 and 19.61), weight of matured shoots (99.27 and 38.46), the number of compound leaves per matured shoot (95.32 and 21.10) and fresh leaf yield per plant (95.86 and 21.01) showed high heritability with high genetic advance. High heritability with high genetic advance as per cent of mean for the character represents selection is effective and this is due to additive gene action. The magnitude of genotypic correlation was higher than the phenotypic correlation for all the traits that indicated inherent association between various characters (Shoba *et al.*, 2020). India is frequently known by enormous biodiversity of medicinal plants. Among them, curry leaf (*Murraya koenigii*) has a lots of bioactive principles and it has been proven as the medicinally important plant. However, less or no attention received by the scientist. Curry leaf is proven as the natural medicinal plant (Ch'ng, 2020). A huge morphological and chemical diversity is reported in curry leaves. Broadly, curry leaf is classified into three morphological types viz., Brown/Gamthi (GM), Regular (RE) and Dwarf (DF) based on growth habit, colour and size of leaves and flavor. Slow growing genotypes with dark brown small and thick leaves having serrated edges are Brown/Gamthi (GM). It is most fragrant type of curry leaf. Whereas, genotypes grow very fast, sometimes turn into small-medium-sized trees and produces exstipulate, bipinnately compound dark leaves with long reticulate venation are referred to as regular type (RE) and this type is available throughout India. Dwarf types (DF) are moderately growing genotypes with spreading branches to form bushy habit and its leaves are light green, exstipulate, bipinnately compound with long reticulate venation and having unique aromacity. Besides, these morphotypes vary for anti-oxidant activity in the order of Gamthi>Dwarf>Regular types (Raghu *et al.*, 2020c).

To study the variability parameters, genotypic and phenotypic coefficient of variation, heritability and genetic advance which will aid in finding traits responsible for the variation between grafted and seedling plants. Different parameters were recorded in which all the traits showed greater PCV % than that of GCV % with a minimum variation which can be considered as the result of environment. Three characters fresh weight of leaf, dry weight of leaf alone and fresh leaf yield had higher GCV and PCV %. All the characters used in this study had higher heritability coupled with genetic advance except for average number of leaflets per compound leaf. From the mean data observed it is found that grafted (GSK) plants performed better for growth and yield (Ponraj *et al.*, 2022). In addition to that curry leaf has natural variability in its growth, yield and biotic stress. Hence the assessment of genetic variability for growth and yield attributes of thirteen curry leaf genotypes were carried out in the present investigation at Horticultural College & Research Institute for Women, Trichy under salt affected soil. Among the plant growth attributes, the highest genotypic and phenotypic variances were

recorded for plant height (879.16 and 955.64 cm), leaf area (308.81 and 329.90 cm²) and the number of mature shoots per plant (28.86 and 31.45) respectively. In this study, the PCV was relatively greater than GCV for all traits observed, however, GCV was near to PCV for the characters like plant height and leaf area inferred that high contribution of genotypic effect for phenotypic expression of such characters. The fresh leaf yield per plant had a significant and positive association with plant height (0.561 and 0.588 cm), plant girth (0.821 and 0.808 cm), internode length (0.651 and 0.596 cm), petiole length (0.732 and 0.753 cm), number of mature shoot per plant (0.647 and 0.665), number of compound leaves (0.455 and 0.544) and leaf area (0.455 and 0.544 cm²). Hence the study concluded that the selection of curry leaf genotypes for yield attributes has high heritability and genetic advance and has a significant positive association among the yield attributing characters which indicated the strong scope of a breeding program in curry leaf (Vidhya *et al.*, 2022). Similarly, a tremendous variability for chemical composition of essential oils in curry leaves was observed with respect to different regions. The variation is highly inherited and is recognized as chemotypes (Rao *et al.*, 2011 a&b). Two main chemotypes with essential oils predominant in monoterpenoids and sesquiterpenoids were recognised in India. The chemotypes of Western Ghats were dominated by monoterpenes such as sabinene (6.90- 40.59%), β -phellandrene (1.39-45.89%) and α -pinene (1.93-63.66%), followed by sesquiterpene like β -caryophyllene (6.68-18.46%). Four chemotypes *viz.*, β -phellandrene, sabinene, α -pinene and β -caryophyllene were reported from Western Ghats. Besides, four other genetically diverse chemotypes of curry leaves such as β -pinene, α -pinene, β -caryophyllene and β -phellandrene were reported from other parts of India (Raghu *et al.*, 2022a).

Genetic diversity is the amount of genetic variability present among individuals of a variety or a population within a species. It is the product of the recombination of genetic material (DNA) during the inheritance process, mutations, gene flow, and genetic drift [1], and it results in variations in DNA sequence, epigenetic profiles, protein structure or isoenzymes, physiological properties, and morphological properties. The diversity among plant and animal populations is determined by the hereditary material present in the reproducing members of the population. Genetic diversity is the main driving force for the selection and evolution of populations. Within crop species, the selection of individuals can be natural or artificial, depending upon the variation present [2]. Genetic diversity can be distilled down to the alleles of a gene present in the population, their effects, and their distribution. Genetic diversity is crucial for a healthy population as it maintains different genes that could lead to resistance to pests, diseases, or other stress conditions. It also enables individuals to adapt to various biotic and abiotic stresses. Under environmental changes, different crop varieties survive due to the presence of genetic variation, which enables the varieties to adapt. However, the varieties with little or no genetic diversity could become susceptible to biotic and abiotic stresses. Genetic diversity helps breeders to maintain the crossbred varieties, which leads to sustaining the desirable traits of the varieties, such as quality characteristics and tolerance to various stresses (Salgotra and Chauhan, 2023).

BREEDING

Germplasm

Curry leaf is an aromatic tropical and sub-tropical plant originated from India. Besides its culinary purpose, curry leaf is known for its medicinal and industrial applications. Based on ethno-botanical reports and other floral distribution studies, the germplasm rich regions of curry leaf in India could be identified into six zones as Foot hills of Himalaya, North-East region, Middle India, Eastern Ghats, Western Ghats and Andaman – Nicobar Islands. With respect to color and size of leaves, habitat and flavor, the curry leaf plant is classified as brown/ gamthi, regular and dwarf morphotypes. Four genetically diverse chemotypes of curry leaves such as β -pinene, α -pinene, β -caryophyllene and β -phellandrene exist in India. Due to its nutritional

value, increasing export potential, less input, lower cost of cultivation, assured income, perennial nature and constant demand in local, national and international markets, the curry leaf is being cultivated on commercial scale in recent years in India (Raghu, 2020). Based on several ethno-botanical reports and other floral distribution studies, the germplasm rich regions of curry leaf could be identified into six zones for future exploration and genetic improvement in India (Fig. 2) (Raghu, 2020d).

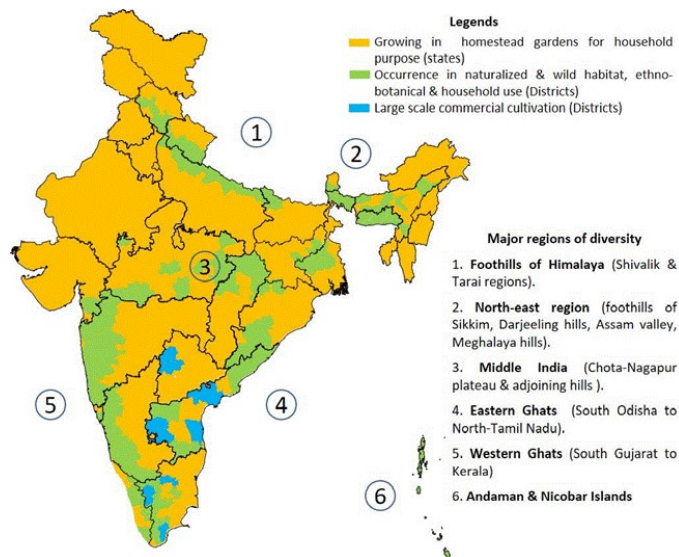


Fig. 2. Diversity map of curry leaves in India

Lately, ICAR-Indian Institute of Horticultural Research (ICAR-IIHR), Bengaluru, has initiated comprehensive breeding programme in curry leaf. Till now, the institute has collected more than 150 germplasm from different parts of India covering Himachal Pradesh, Odhisa, Karnataka, Tamil Nadu and Kerala, and successfully established a field gene bank to conserve them. Germplasm characterization with respect to different morphological traits, bio-chemical and nutritional traits including chemical profiling for essential oils are being taken up in different seasons. Further, germplasm augmentation is being done through regular exploration programmes concentrating in different states and regions (Raghu *et al.*, 2022a).

Breeding

Despite multiple use and numerous benefits, the curry leaf is still an under-utilized and unexplored vegetable in terms of efforts towards its genetic improvement and area under cultivation. The genetic improvement of curry leaf still is in nascent stage and unsystematic in India. Earlier, few efforts were made to characterize curry leaf germplasm for different morphological and biochemical traits. More often, they are isolated programmes, characterized by limited use of plant genetic resources (PGR), and has narrow genetic base (Raghu *et al.*, 2020c). ICAR-Indian Institute of horticultural Research (ICAR-IIHR), Bengaluru, has initiated comprehensive breeding programme in curry leaf. Till now, it has collected more than 150 germplasm from different parts of India covering Himachal Pradesh, Odhisa, Karnataka, Tamil Nadu and Kerala, and successfully established a field gene bank to conserve them. Germplasm characterization with respect to different morphological traits, bio-chemical and nutritional traits including chemical profiling for essential oils are being taken up in different seasons. Further, germplasm augmentation is being done through regular exploration programmes concentrating in different states and regions (Raghu *et al.*, 2020c). Genetic improvement of curry leaves in terms of germplasm collection, characterization and conservations are still in nascent stage in India. Majority of curry leaf growing farmers on commercial scale have adapted locally available genotypes in which genetic potential for yield, resistance to pests and diseases and information on quality is unknown (Raghu, 2020d). Recently, the research efforts are initiated at ICAR-Indian

Institute of Horticultural Research (IIHR), Bengaluru for genetic improvement of curry leaf for improved yield and quality and resistance pests and disease. Over 100 germplasm of curry leaves were collected from different parts of the country and successfully established in field gene bank at ICAR-IIHR, Bengaluru. Further, efforts are being made to characterize them and registered with national gene bank for further utilization in research programmes in India (Raghu, 2020d). Despite multiple use and numerous benefits, the curry leaf is still an under-utilized and unexplored vegetable in terms of efforts towards its genetic improvement and area under cultivation. The genetic improvement of curry leaf still is in nascent stage and unsystematic in India. Earlier, few efforts were made to characterize curry leaf germplasm for different morphological and bio-chemical traits. More often, they are isolated programmes, characterized by limited use of plant genetic resources (PGR), and has narrow genetic base. Moreover, in majority of the studies, the sampling was done on natural populations, wherein, such samples lack replications and uniform environments. The inferences made from such studies, especially on traits like bio-chemical composition and essential oils content which vary greatly with locations and seasons, often failed to provide comprehensive information regarding extant of genetic base of plant diversity (Raghu *et al.*, 2022a). Further, some other studies have done nutrient analysis and profiling in curry leaf. However, in those studies, genotype x environment interaction components has not been dissected for nutritional related traits. Thus, it implied that, no comprehensive efforts have been made to collect and conserve curry leaf germplasm covering different geographical regions, and characterize under uniform environmental conditions (Raghu *et al.*, 2022a).

Plant genetic resources (PGRs) are the total hereditary material, which includes all the alleles of various genes, present in a crop species and its wild relatives. They are a major resource that humans depend on to increase farming resilience and profit. Hence, the demand for genetic resources will increase as the world population increases. There is a need to conserve and maintain the genetic diversity of these valuable resources for sustainable food security. Due to environmental changes and genetic erosion, some valuable genetic resources have already become extinct. The landraces, wild relatives, wild species, genetic stock, advanced breeding material, and modern varieties are some of the important plant genetic resources. These diverse resources have contributed to maintaining sustainable biodiversity. New crop varieties with desirable traits have been developed using these resources. Novel genes/alleles linked to the trait of interest are transferred into the commercially cultivated varieties using biotechnological tools. Diversity should be maintained as a genetic resource for the sustainable development of new crop varieties. Additionally, advances in biotechnological tools, such as next-generation sequencing, molecular markers, in vitro culture technology, cryopreservation, and gene banks, help in the precise characterization and conservation of rare and endangered species. Genomic tools help in the identification of quantitative trait loci (QTLs) and novel genes in plants that can be transferred through marker-assisted selection and marker-assisted backcrossing breeding approaches (Salgotra and Chauhan, 2023).

Varieties

Towards this end, two improved varieties of curry leaf namely, DWD-1 and DWD-2 (Suhasini) were developed and released by University of Agricultural Sciences (UAS), Dharwad. Basically, these two varieties were developed by clonal selections from the germplasm collected from Western Ghats. Both have good aroma and suitable for fresh leaves. The oil content reported to be 5.22% and 4.09% in DWD-1 and Suhasini, respectively. DWD-1 is cold sensitive and shows poor growth in winter season. Whereas, Suhasini is insensitive to low temperature and thus produces higher yield than DWD-1. Besides, several local landraces and farmers' varieties are being popularly grown by the farmers; these were selected based on appearance, fragrance and response to local environments (Raghu, 2020d).

Further, an inclusive field gene bank contains broad based germplasm in terms of number, regions and traits, is lacking in curry leaf. In spite of lack of comprehensive PGR activities in curry leaf, a few and scanty breeding initiatives were made in the past. Towards this end, two improved varieties of curry leaf namely, DWD-1 and DWD-2 (Suhasini) were developed and released by University of Agricultural Sciences (UAS), Dharwad. Basically, these two varieties were developed by clonal selections from the germplasm collected from Western Ghats. Both have good aroma and suitable for fresh leaves. The oil content reported to be 0.522% and 0.409% in DWD-1 and Suhasini, respectively. DWD-1 is cold sensitive and shows poor growth in winter season. However, two improved varieties of curry leaves namely, DWD-1 and DWD-2 (Suwasini) are genetically distinct genotypes, released from University of Agricultural Sciences (UAS), Dharwad for commercial cultivation. Suhasini is insensitive to low temperature and thus produces higher yield than DWD-1. Besides, several local landraces and farmers' varieties are being popularly grown by the farmers; these were selected based on appearance, fragrance and response to local environments. Senkaampu is such local landraces or farmers' variety are being popularly grown in many parts of Tamil Nadu. It has pigmented petiole, shiny and leathery leaves with good fragrance. It has huge local demand for fresh leaves (Raghu *et al.*, 2022a). Senkaampu is such local landraces or farmers' variety are being popularly grown in many parts of Tamil Nadu. It has pigmented petiole, shiny and leathery leaves with good fragrance (Raghu *et al.*, 2020c). Besides, a local landrace called Senkaampu is very popular in different parts of Tamil Nadu due to its good aroma and high oil content (Raghu, 2020d).

Local cultivar (Vasanthkumar *et al.*, 2024).

DWD 1: It developed at Dharwad's University of Agricultural Sciences. It is a clone of root suckers from a single plant. The leaves are glossy, dark green (with 0.1629 mg of chlorophyll per gramme of fresh leaf), and very fragrant. It has a poor bud burst because it is vulnerable to low temperatures during the winter. With a 5.22 percent oil content, the leaves can be desiccated at 50°C without losing any of their quality and ground into a powder.

DWD2: At UAS, Dharwad, it was developed. It is an unidentified seedling progeny. The leaves are less fragrant and have a modest pale green colour. It is considerably better than DWD 1 in terms of bud burst count, internodal length, and shoot growth—it grows eight times faster than DWD 1. It is also less sensitive to low temperatures.

Senkaampu: Is a local cultivar grown in different parts of T.N (especially Karamadai tract of Coimbatore district. The petiole is purplish red in colour, the leaves have good aroma and flavour.

CULTIVATION

The harvesting of Curry Leaves Plant is easy and improves the future growth of the plant. Once it has grown you can pluck off the leaves. You can use these fresh aromatic leaves to flavor delicious stews and soups (SGPL, 2021). Naturalized forest and homestead gardens habitation, the curry leaves are also being cultivated in large commercial scale in several districts of Southern India due to increasing export potential, low inputs for cost of cultivation, adaptability to small and marginal lands, assured income, perennial nature, and constant domestic demand in local markets. The large scale commercial cultivation of curry leaves is seen in Guntur, Nellore, Anantapur and Krishna districts of Andhra Pradesh, Sanga Reddy, Medak, Siddipet, Kama Reddy and Nizamabad districts of Telangana and Coimbatore, Tiruppur, Selem and Thoothukudi districts of Tamil Nadu (Raghu, 2020d). Curry trees can grow in a full sun to part shade location. If you are growing yours in a container in a cooler region, give it full sun. This plant should never be exposed to temperatures below 40°F. Young plants that are under a year old shouldn't be exposed to full sun in extremely warm regions. If temperatures climb to 100°F, keep them in a partially shady spot. Plants need loose, rich, well-draining soil. The earth should be slightly acidic, with a pH of 5.6-6.0. Curry leaf dislikes wet feet. If

your soil has poor drainage, work in some sand to improve it. Other than that, this plant isn't too fussy. I like to work well-rotted manure or compost into the earth when planting to give the bush a good start in its preferred conditions, since I have poor soil. Regular pruning or picking of leaves is essential to promote fresh foliage growth. Cut off dead leaves and branches from the curry leaf plant to maintain it (SGPL, 2021).

Pruning isn't necessary for plant health, but it can help to increase your harvest. Prune in the spring if you want to control the plant's size and encourage bushier growth. If you plan to harvest the leaves, pinch off the buds that form on the plant. These commonly form in the spring, but the plant flowers sporadically during the spring, summer, and fall, so keep an eye out. These will open into beautiful, fragrant flowers, but the blossoms come at the expense of leaf growth. Since I don't use a ton of leaves in my cooking, I let my plant flower. The blossoms are so pretty and they smell so good, I don't want to go without. Curry leaf plants are self-fertile. If you let the flowers grow. Snip off the flowers before they mature into fruits with a sharp pair of scissors, but you can allow them to form if you want to use them medicinally or to save seeds for planting. Just keep in mind that when a plant starts developing flowers and fruits, it generally stops putting its energy into growing leaves. The flowers have a strong, sweet scent, and birds like to eat the berries – and spread the seeds. Within ten years, a full-sized standard tree should be potted in a 30-gallon container. If you grow the miniature or dwarf variety, these can be potted in three-gallon or five-gallon containers respectively when fully mature (Lofgren, 2021).

Regardless of size, the plant should be fully productive by year five. During years one through four, the harvest will begin to increase gradually each year. Standard varieties should be about six feet tall in two years, and you can begin harvesting regularly at that point. Dwarf and miniature (gamthi) types take a bit longer to reach a harvestable size of about half of their mature height, with the miniature plants taking up to five years. Harvesting can be done in one of two ways: You can pluck leaves as you need them. Or you may take a larger harvest two or three times a year. The second method means cutting off branches every two months during the growing season. Use scissors or pruners to cut back the branches. Leave a few inches at the base of each branch. Never take more than half of the leaves at a time. Don't be shy about harvesting. In fact, it promotes bushier growth that will allow you to harvest leaves regularly in the future. As long as you don't take more than half of the leaves at a time, new growth will continue to pop up and replace what you've removed (Lofgren, 2021).

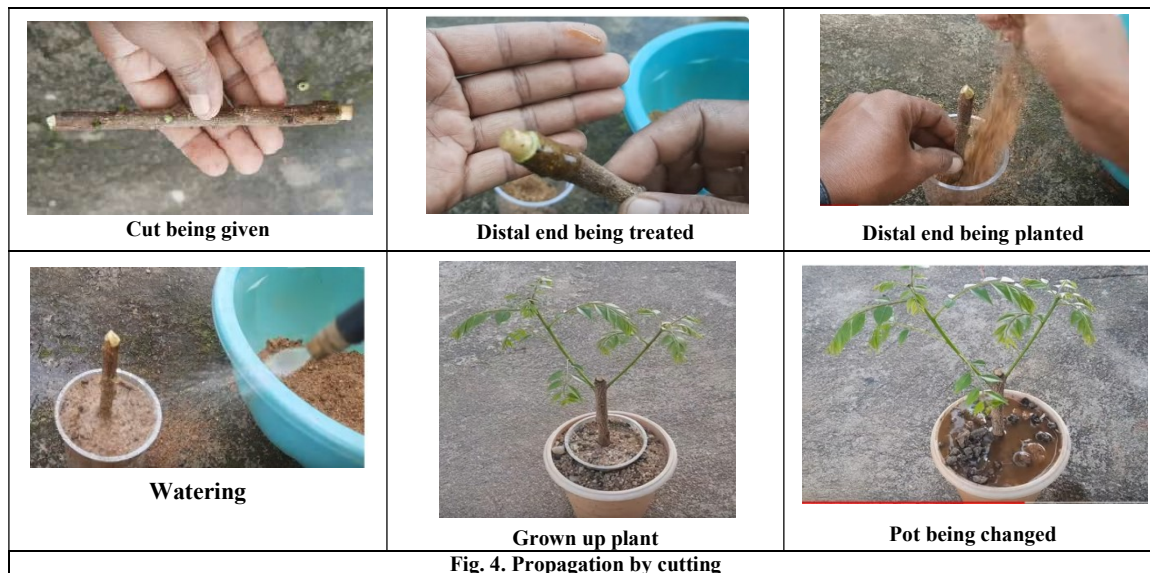
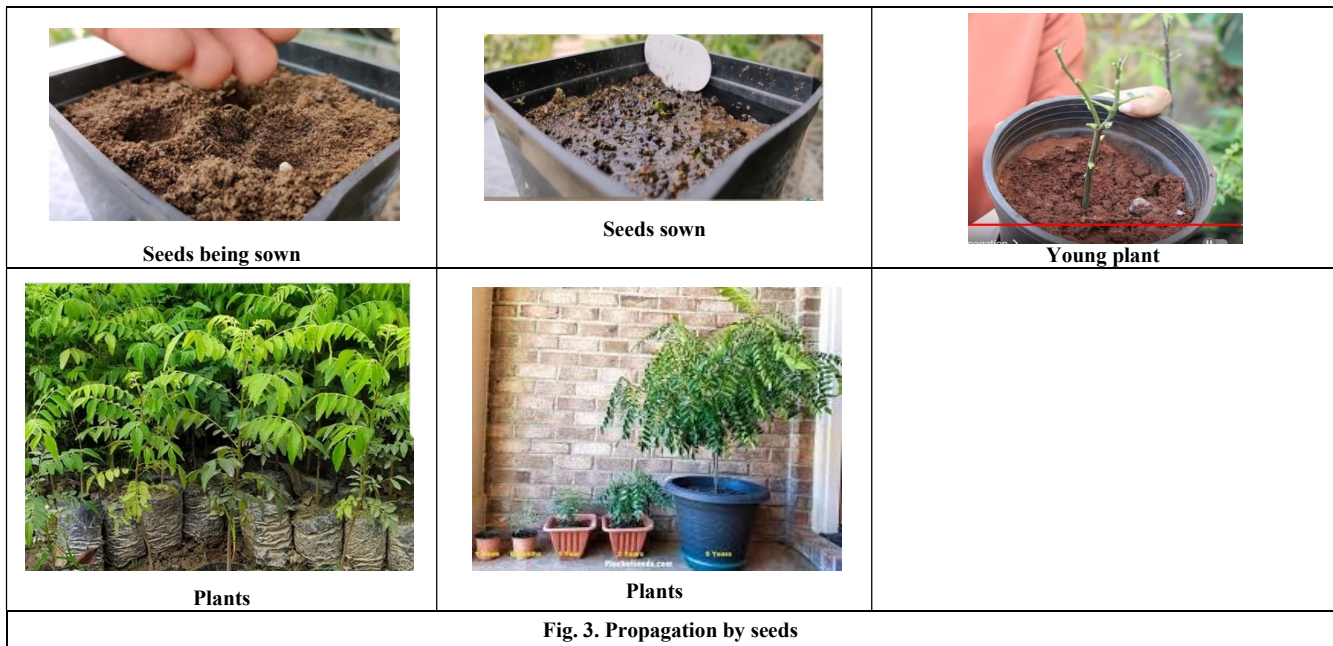
Native to India, the tree loves the full sun and grows best in it. While the plant is in the growing stage, avoid exposing it to the harsh afternoon sun for a longer duration of time. Once established, you don't have to worry much about it (Suyash, 2024). Using well-draining soil, a general potting soil mix, or soil that is specifically designed for growing citrus trees is ideal. The soil should be light and airy with plenty of organic matter to help retain moisture and provide nutrients. A pH of 6.5–7.5 is ideal for a curry tree. If the soil is too acidic, you can add powdered lime to raise the pH (Suyash, 2024). Curry trees flourish in a warm and humid climate and require frequent watering. The tree should be watered when the top inch of soil is dry, using enough water to saturate the root area thoroughly. Water the tree deeply and slowly, allowing the water to penetrate the soil (Suyash, 2024). In the beginning, it's a slow grower and reaches a height of 6-10 inches in a year (depending on the climate and growing conditions), so give it its time to settle (Suyash, 2024). For best results, use a slow-release fertilizer specifically designed for tropical plants. This type of fertilizer should be applied every 3-4 months during the growing season. Additionally, you may want to add a small amount of a balanced fertilizer with a ratio of 10-10-10 once a month during the growing season. Be sure to read and follow the manufacturer's instructions for application amounts and frequency (Suyash, 2024). Pruning a curry tree is relatively easy and can be done any time of year. The best time to prune a curry tree is in the spring or early summer when the tree is actively growing. Pruning in

the late summer or fall should be avoided as it can weaken the tree and cause it to be more susceptible to disease or pests. When pruning, it is important to remove any dead, diseased, or damaged branches. This will encourage healthy new growth. It is also important to thin out the tree's canopy to increase airflow and light. This will help reduce the disease risk and make the tree look more attractive. Be sure to remove any suckers that are growing from the base of the tree. These should be removed as they can take away from the growth of the main branches (Suyash, 2024). In order to encourage leaf production, the berries should be picked off. If fruit is desired, leave the berries to maturity (Grant, 2023). Leaf-feeding caterpillars, aphids, mealybugs, and scale insects can attack the plant. Root rot, powdery mildew, leaf spot, and canker that appear in wet conditions. Use an insecticidal soap or a neem oil solution to keep pests at bay. For diseases, avoid overwatering the plant and ensure it gets plenty of sunlight (Suyash, 2024). Leaves are harvested by picking the leaves off the stem individually. You can also use scissors or pruning shears to make the process easier. To harvest, start at the end of the stem and work your way down, picking only the leaves that are fully developed. Do not take all the leaves off the stem at once, as this will leave the plant vulnerable to damage from heat or pests. Once the leaves are harvested, they can be used fresh or dried later (Suyash, 2024).

Propagation

You might be able to find plants at your local nursery or Asian market. You can also buy seeds and plants online. *M. koenigii* is typically propagated by rooting cuttings, but you can also try growing it from seed if you're patient (Lofgren, 2021). You can propagate curry leaf trees by planting seed, but keep in mind that this isn't a quick process. It can take two years before your plant becomes established enough for you to start harvesting the leaves regularly. Purchase fresh dried seeds for the best chance of germination. Older seeds don't germinate well. Remove the hard outer shells by rubbing the seeds, which are actually the pits of the berries, between your hands. If that doesn't work, put the seeds in a plastic bag and roll a rolling pin over them. If you're using fresh berries, soak them for 24 hours to extract the seed inside. After soaking, you can gently rub off the flesh and pulp that surrounds the seed. To start seeds indoors, sow them a third of an inch deep in potting soil and keep it moist. You can cover the container with plastic wrap with holes poked in it to help retain moisture, effectively creating a mini greenhouse. Seeds need a soil temperature of at least 68°F to germinate, so use a heat mat if necessary. The germination rate of these seeds is pretty low, so try planting several seeds per tray cell to improve your chances of producing a healthy plant. After the seedlings emerge, thin them out to one seedling per cell as needed. Outdoors, sow directly into the ground when daytime temperatures are consistently above 65°F. Standard sized plants should be planted four to five feet apart or the same distance away from any structures. Keep the soil moist until the seedlings emerge, in about two to three weeks. When your curry leaf plant is about six months old, it's time to start pruning. When a healthy seedling has formed six or more branches with several developed leaves on each, pinch back or prune two of the branches to encourage bushier growth. The goal is to encourage the plant to become bushy with lots of offshoots rather than spindly and tall (Fig. 3) (Lofgren, 2021). In the spring, cut a three to six-inch piece of stem that has at least three sets of leaves from a mature, healthy plant. Clip the branch as close as possible to the main stem and then cut the base at a 45-degree angle. Remove the lowest set of leaves and dip the bottom in rooting hormone powder. Fill a container with soilless potting mixture. I like to use a four- or six-inch biodegradable pot because they're easy to transplant, but any container that size will work (Fig. 4) (Lofgren, 2021).

Curry Leaves tree propagation can be achieved by either seed or vegetative means. Seeds should be sown in a well-draining soil mix and placed in a warm, sunny spot. Propagate it from cuttings (suckers of the plant) or seeds — remove the hard outer shell before sowing for faster germination. Use fresh seeds for a high germination rate. Sow them in good quality potting soil.



If your temperature is not warm around 65 F (20 C), layer it with polyethylene or keep it in the greenhouse because the seeds germinate at warm temperatures (SGPL, 2021). Curry leaf plants may be grown from cuttings or seed. Seeds should be scarified or have the husk removed prior to planting. Fresh seed shows the greatest rate of germination. Sow the seeds in potting soil and keep them damp but not wet. They will need a warm area of at least 68 degrees F. (20 C) to germinate. Growing curry leaf tree from seed is not an easy task because germination is fickle. This method will also take years before the tree is large enough for harvest. You can take a cutting of fresh curry leaves with petiole or stem to start a plant. Treat the leaves as a cutting and insert them into a soilless potting medium. Take a piece of stem from the tree that is about 3 inches (8 cm) long and has several leaves. Remove the bottom 1 inch (2.5 cm) of leaves. Immerse the bare stem into the medium and mist thoroughly. It will root in about three weeks if you keep it warm and moist. This method is the easiest and most efficient (Grant, 2023). Vegetative propagation can be accomplished by taking cuttings from mature trees and planting them in a potting mix. The cuttings should be taken from healthy branches and should be about 3-4 inches in length. Once planted, the cuttings should be watered regularly and placed in a sunny spot (Suyash, 2024). Plant it in the sunniest spot in your garden, and do regular watering in the next two months. Pinch off its white flowers in the first two years to appreciate healthy growth. Once settled, it'll start to grow up quickly (Suyash, 2024).

Seeds must be ripe and fresh to plant; dried or shriveled fruits are not viable. The skin must be peeled off, and this is recommended before planting. One can plant the whole fruit, but it is best to remove the pulp before planting in a potting mix that is kept moist but not wet. Stem cuttings can be also used for propagation. In India, it is mainly planted privately, but also cultivated commercially to a small extent (Wikipedia, 2024). In general, *M. koenigii* has been propagated by seeds, which is usually unreliable due to low viability and death of young seedlings under natural conditions. One year old root suckers are also used as planting material. Micropropagation through axillary shoot multiplication and shoot bud regeneration offers an alternative means of vegetative propagation. A new curry leaf plant can be easily grown from curry leaf plant seeds. The seeds germinate at temperature around 21°C (Vasanthkumar *et al.*, 2024).

Preserving

You can store fresh leaves in the refrigerator for two weeks in a sealed bag. Wait to wash them until just before using. You can also freeze the leaves, though they'll lose their color and a little flavor. Remove the stems, and wash and dry the leaves. Toss leaves in vegetable oil until they're lightly coated. I use about a tablespoon per cup of leaves. Place the leaves in resealable plastic bags, press out the air, and freeze for up to six months. If you have a particularly large harvest, you can also dry the leaves. These will have a milder flavor

than when they are fresh. Place them in a single layer on a screen and put the leaves in a protected area with good air circulation until they are crisp and dry. You can also place the leaves in a food dehydrator. They will keep in a cool, dark place in a sealed container for up to a year. It's delicious mixed into sour cream as a dip, tossed with pasta, or used as a pizza topping or sandwich spread (Lofgren, 2021).

Main component responsible for flavor: The major constituent responsible for the aroma and flavor has been reported as pinene, sabinene, caryophyllene, cadinol and cadinene (Singh *et al.*, 2014). serves as an important part in soap making ingredients, lotions, massage oils, diffusers, potpourri, scent, air fresheners, body fragrance, perfume oils, aromatherapy products, bath oils, towel scenting, spa's, incense, facial steams, hair treatments, and more. There are several methods to extract essential oil from herb and spices like steam distillation, hydrodistillation, and solvent extraction but this study focus on a new, applicable method of essential oil extraction that is ultrasonic-assisted solvent extraction method. This extraction method is a combination of solvent extraction and ultrasonic extraction method. The steps required for the preparation of the material prior to extraction (including aspects concerning plant selection, collection, identification, drying, grinding and weighing) and analyzing method for the essential (Singh *et al.*, 2014). The major constituent responsible for the aroma and flavor has been reported as pinene, sabinene, caryophyllene, cadinol and cadinene. Essential oils from *M. koenigii* serves as an important part in soap making ingredients, lotions, massage oils, diffusers, potpourri, scent, air fresheners, body fragrance, perfume oils, aromatherapy products, bath oils, towel scenting, spa's, incense, facial steams, hair treatments, and more. There are several methods to extract essential oil from herb and spices like steam distillation, hydrodistillation, and solvent extraction but this study focus on a new, applicable method of essential oil extraction that is ultrasonic-assisted solvent extraction method (Singha *et al.*, 2014). Fresh leaves may contain up to 2.6% essential oil. The following aroma components have been identified (in parentheses, the content in mg/kg fresh leaves): beta-caryophyllene (2.6 ppm), beta-gurjunene (1.9), beta-elemene (0.6), beta-phellandrene (0.5), beta-thujene (0.4), alpha-selinene (0.3), beta-bisabolene (0.3), furthermore limonene, beta-trans-ocimene and beta-cadinene (0.2 ppm) (KSSDB, 2024).

Uses of Curry Leaves: Curry Leaves Plant is often used to add flavor to chutneys, rice, soups, stews, dals, curries, vegetable dishes, chicken dishes, and so much more. For best flavor, it is most suggested that Curry Leaves Plant should be fried first in oil. Then, you can add the sauteed leaves to the dish while other ingredients are cooking for taste (SGPL, 2021). Curry leaves have the strongest flavor and aroma when fresh. In spite of the name, curry leaf plant does not taste like the curry spice. It is often used in curry seasoning, however. The leaves are often used in medicinal concoctions. Leaves, roots, and bark are made into tea to calm an upset stomach. Externally, the leaves may be ground up and made into a paste to apply to bites and skin eruptions. The leaves have natural antibacterial and anti-inflammatory properties. Curry leaves are high in iron and help build the blood and fight anemia. In culinary uses, the leaves are used in many dishes. They flavor fish and beef stews, feature in a yogurt drink, and add depth to chutney and pickles. It is recommended to harvest leaves fresh for use, as they lose flavor when dried. The leaves may be frozen for later use. You can also dry the leaves and crush them for use. Store them in a sealed glass jar out of light and use them within a couple of months. Since they lose flavor quickly, growing curry leaf trees is the best way to have a good, constant supply of this flavorful herb (Grant, 2023). Curry leaves are extensively used in Southern India and Sri Lanka (and are absolutely necessary for the authentic flavour), but are also of some importance in Northern India. They have been introduced to Malaysia by the many South Indian (mostly Tamil) immigrants during the British colonial era. Outside the Indian sphere of influence, they are rarely found.

In Sri Lanka, the delicious chicken and beef curries are flavoured with curry leaves; the leaves are furthermore used for kottu roti, vegetables and sliced bread which are quickly fried together (KSSDB, 2024). Throughout history, curry leaves have played a pivotal role in traditional Indian cuisine, adding a distinct aroma and flavor to a wide range of dishes. These aromatic leaves have been a staple in the culinary landscape of South India for centuries, where they are often used in tempering, imparting a unique and irreplaceable essence to various dishes. In traditional cooking, curry leaves are often sautéed in oil or ghee along with other spices to release their fragrant oils, which infuse the entire dish with their unmistakable essence. Beyond their traditional uses, curry leaves have also found their way into modern culinary practices, where their versatility has been embraced by chefs and home cooks alike. From lending a subtle depth to curries and stews to being incorporated into marinades, chutneys, and even beverages, curry leaves have evolved to become a versatile ingredient in contemporary cooking. Their distinctive flavor profile has also made them a popular choice for infusing oils, adding a fragrant touch to a variety of culinary creations. In addition to their aromatic qualities, curry leaves have also gained recognition for their potential health benefits. With their rich antioxidant content and purported medicinal properties, these leaves have garnered attention for their potential role in promoting overall well-being. As a result, they have been increasingly incorporated into modern wellness-focused recipes, from herbal teas to health tonics and beyond. As global interest in diverse cuisines continues to grow, curry leaves have transcended their traditional uses and made their mark on international culinary scenes. As chefs and food enthusiasts explore new ways to incorporate exotic flavors into their dishes, the unique essence of curry leaves has found its way into fusion cuisine, creating innovative and unexpected flavor combinations that captivate the palate. Whether used in traditional recipes or reimagined in modern culinary creations, curry leaves continue to be a cherished and versatile ingredient with a rich culinary legacy (Savorysuitcase, 2024b).

The fresh leaves are an indispensable part of Indian cuisine and Indian traditional medicines. They are most widely used in southern and west coast Indian cooking, usually fried along with vegetable oil, mustard seeds and chopped onions in the first stage of the preparation. They are also used to make thoran, vada, rasam, and kadhi; additionally, they are often dry-roasted (and then ground) in the preparation of various powdered spice blends (masalas), such as South Indian sambar masala, the main seasoning in the ubiquitous vegetable stew sambar. The curry leaves are also added as flavoring to masala dosa, the South Indian potato-filled crepes, made with a mildly probiotic, fermented lentil and rice batter. The fresh leaves are valued as seasoning in the cuisines of South and Southeast Asia. In Cambodia, curry leaves are roasted and used as an ingredient for *samlor machu kroeung*. In Java, the leaves are often stewed to flavor *gulai*. Though available dried, the aroma and flavor are greatly inferior. The oil can be extracted and used to make scented soaps. The leaves of *Murraya koenigii* are also used as a herb in Ayurvedic and Siddha medicine in which they are believed to possess anti-disease properties, but there is no high-quality clinical evidence for such effects. The berries are edible, but the seeds may be toxic to humans (Wikipedia, 2024).

Curry leaves give off a citrus-like flavor when used fresh in dishes. When the leaves are cooked in oil, they release the most flavor. They go very well with vegetable, fish, seafood, coconut sauces, stews, and chutneys. Curry leaves are used in ayurvedic medicine to control heart disease and treat infections as well as inflammations. The leaves are rich in antioxidants and vitamin C. They also have antimicrobial properties. Studies have shown that curry leaves can reduce cholesterol levels in animals. The leaves may also prevent Alzheimer's disease because they have pro-cholinergic effects on mice that were fed curry leaves. They are also said to have anti-diabetic properties. Curry leaves are efficient at treating anemia because they contain iron and folic acid. Folic acid encourages the body to absorb iron. It also protects the liver from damaging due to drinking or eating fish (Heritagegarde, 2024) Leaves are most flavoursome when used fresh, straight off the tree. The fresh leaves

are an indispensable part of Indian cuisine and Indian traditional medicines. They are most widely used in southern and west coast Indian cooking, usually fried along with vegetable oil, mustard seeds and chopped onions in the first stage of the preparation (Jekkas, 2024).

Industrial Uses

Fresh leaves on steam distillation under pressure yields 1.6-3.7 mL volatile oils called curry leaf oil per kilogram (kg) of biomass. The leaf oil is characterized by specific gravity of 0.9748 at 25^oC, saponification value of 5.2 and acid value of 3.8. Similarly, the mature fruits also yield a yellow colour volatile oil with specific gravity of 0.872 at 13^oC and boiling point of 173.74^oC, having neroli-like odour and pepper like taste accompanied by agreeable sensation of coolness on the tongue. Similarly, yellow colour oil extracted from the seeds is known as limbolee oil. The leaf oil is used as a fixative for a heavy type of soap. Perfumes. The essential oils extracted from other parts are also used in cosmetics industry and aromatherapy. Besides, the extracts from berries of curry leaf plant are used to prevent oxidative damage of meat and meat products. The curry leaves are incorporated in functional poultry meat finger sticks to improve lipid stability and antimicrobial quality of the products. This indicates that the effective use of curry leaves as an alternative to synthetic food preservatives in functional food industries. Besides, the curry leaf oil is also exported from India. The age of the leaves influences the oil composition, with advancing maturity there is gradual decrease in volatile oils and oleoresin (acetone extracted). The specific gravity of curry leaf oil is 0.97 while refractive index is 1.50 and optical rotation is +48 at (25^oC). The saponification value of this oil is 5.2 and after acetalation it is 54.6 (Raghu, 2020d).

Medicinal Uses: The different parts of curry leaf plant have many applications in Ayurveda and other traditional medicine systems. Curry leaves are the richest source of carbazole alkaloids, which have bioactive functions like anti-oxidant, anticancer, antidiabetic, and antiulcer. The carbazole alkaloids, mahanimbine and koenigine present in these leaves showed higher anti-oxidant activities. The extracts from roots, bark and leaves are used in aboriginal medicine as tonic, anthelmintic, stomachic, analgesic, and as appetizing, carminative and stimulative agents for treating influenza, piles, itching, fever, dropsy, asthma, bronchial eruptions, diarrhoea, body aches, kidney pains, vomiting, fresh cuts and bites of poisonous animals. The green leaves eaten raw for cure of dysentery. The pulped bark and root of curry leaf plant are externally applied to cure eruptions and bites of poisonous animals (Raghu, 2020d). Curry tree leaves have been used in Ayurvedic medicine for millennia. It has been used in this medical tradition to treat stomach issues, diarrhea, and bruising. The leaves contain antioxidants, beta carotene, and vitamins C, A, B, and E. They also have iron, fiber, calcium, phosphorus, and amino acids. Studies indicate they have antimicrobial and anti-oxidative properties (Lofgren, 2021).

A Note of Caution: While the berries are edible and have also been used in Ayurveda and Unani systems of medicine, the seeds of the plant are poisonous to mammals and humans – so don't eat them! (Lofgren, 2021).

Traditional uses: The bark and the roots are used as a stimulant by the physicians. They are also used externally to cure eruptions and the bites of poisonous animals. The green leaves are stated to be eaten raw for curing dysentery, and the infusion of the washed leaves stops vomiting. Curry leaves are also used in calcium deficiency. It has Vitamin A, Vitamin B, Vitamin C, Vitamin B2, Calcium and iron in plenty. Its nutritional value benefits both the young and the old alike. Women who suffer from calcium deficiency, osteoporosis etc can find an ideal natural calcium supplement in curry leaves. Fresh juice of curry leaves, with lime juice and sugar, is an effective medicine in the treatment of morning sickness, nausea and vomiting due to indigestion. One or two teaspoons of juice of these leaves mixed with a teaspoon of lime juice may be taken in these conditions. The curry leaves, ground to a fine paste and mixed with buttermilk, can also be taken on an empty stomach with beneficial results in case of stomach

upsets. Also used as laxative. Boils and similar eruptions appear on skin during summer. Most of the boils tend to subside over time, but some may persist and remain painful. Curry leaves come handy in treating such conditions. A paste made of curry leaves is applied on these persistent boils for quick relief. Along with mint leaves and coriander leaves, curry leaves can be used in treating excessive pitta conditions. Curry leaves can be used with effective result to treat burn, bruises and skin eruption. Cataract development can be prevented by using fresh juice of curry leaves. Kidney pain can be cured by using juice of root of *Murrayakoenigii*. It can be used in preventing premature greying of hairs (Singha *et al.*, 2014).

Pharmacological activity: Curry leaves are rich in many minerals and trace minerals such as Iron, zinc and copper. Therefore, researchers recommended in a study published in January 2007 in "Chemico-Biological Interactions" that people with diabetes may benefit from the addition of curry leaves in the diet. Minerals found in curry leaf extract are important for maintaining normoglycemia, or the normal glucose content of the blood. This is done by the activation of pancreatic beta cells, which are responsible for the creation of insulin. While the nutrients in curry account for only about 1 to 2 percent of the required daily intake for these elements, they are bioavailable, or readily usable by the body. Therefore, the researchers suggested that curry leaves may be useful for the management of diabetes. A scrutiny of literature reveals some notable pharmacological activities of the plant such as activity on heart, Anti diabetic and cholesterol reducing property, antimicrobial activity, antiulcer activity, antioxidative property, cytotoxic activity, anti diarrhea activity, phagocytic activity (Singha *et al.*, 2014). Curry leaves are rich in many minerals and trace minerals such as Iron, zinc and copper. Therefore, researchers recommended in a study published in January 2007 in "Chemico-Biological Interactions" that people with diabetes may benefit from the addition of curry leaves in the diet. Minerals found in curry leaf extract are important for maintaining normoglycemia, or the normal glucose content of the blood. This is done by the activation of pancreatic beta cells, which are responsible for the creation of insulin. While the nutrients in curry account for only about 1 to 2 percent of the required daily intake for these elements, they are bioavailable, or readily usable by the body. Therefore, the researchers suggested that curry leaves may be useful for the management of diabetes. A scrutiny of literature reveals some notable pharmacological activities of the plant such as activity on heart, Anti diabetic and cholesterol reducing property, antimicrobial activity, antiulcer activity, antioxidative property, cytotoxic activity, anti diarrhea activity, phagocytic activity (Singh *et al.*, 2014).

The antioxidative properties of the leaves extracts of *Murraya koenigii* using different solvents were evaluated based on the oil stability index. *M. koenigii* possesses statistically significant hypoglycemic potential in STZ-induced diabetic rats. The *M. koenigii* extract appeared to be more effective than glibenclamide, a known antidiabetic drug. It also revealed hepato-protective activity against ethanol-induced hepatotoxicity. Chronic ethanol consumption diminishes the cellular antioxidant levels through free radical induced injury causing hepatitis and cirrhosis with mortality in severe cases. It also shows antibacterial activity against *S. typhi* and *E. coli*. Carbazole derivatives are well known for their various pharmacological activities, including anti-HIV, anticancer, antibacterial and antifungal activities. A series of substituted carbazoles, termed N-alkylated 3,6-dihalogenocarbazoles, that exhibit fungicidal activity against *C. albicans* and the emerging pathogen *Candida glabrata*. The most potent fungicidal compounds of this series were characterized *et al.*, by minimal fungicidal concentration (MFC) between 8.5 and 25 μ M (Singh *et al.*, 2014). Curry leaves can come in four different forms: fresh, dried, powdered and cooked.

Fresh: Fresh curry leaves are the preferred form for cooking. Fresh leaves may be used directly after harvesting from a curry leaf tree. They also may be placed or vacuum-packed in plastic bags and refrigerated or frozen after harvesting, which keeps them fresh from

one week to two months. Fresh curry leaves are generally found in the freezer section of stores (Singha *et al.*, 2014).

Dried: Curry leaves may be air dried or oven dried, producing leaves that have a longer shelf life. According to Gernot Katzer's Spice Pages, some recipes require the baking or toasting of fresh curry leaves before the leaves are added as a flavoring. Dried leaves are also available commercially (Singha *et al.*, 2014).

Powdered: Powdered curry leaves are also called for in some recipes and powdered curry is also available commercially. After being dried, curry leaves can be pulverized, producing a concentrated powder. Powdered curry leaves, though, should not be confused with curry powder. Commercial curry powder is usually a mixture of many spices, while powdered curry leaf is a powdered version of the actual dried curry leaf (Singha *et al.*, 2014).

Cooked: Sauteed or fried curry leaves are prepared by the cook or chef prior to or during the cooking process. Some recipes require that fresh curry leaves be cooked before being added as flavouring. Such sauteed or fried curry leaves would not generally be purchased in advance. Instead, curry leaves would be purchased fresh, or perhaps dried, and then cooked in the kitchen (Singha *et al.*, 2014).

Value Addition (Vasanthkumar *et al.*, 2024).

Dried Curry Leaves- The most common value-added product, dried curry leaves retain their aroma and can be used as a convenient substitute for fresh leaves in cooking.

Curry Leaf Powder-Dried leaves are ground into a fine powder, perfect for enhancing the flavour of various dishes. This powder is a versatile seasoning for curries, soups, and rice.

Curry Leaf Extracts-Extracts of curry leaves are used in the production of dietary supplements due to their potential health benefits, including antioxidant and anti-inflammatory properties.

Curry Leaf Oil-Steam distillation of curry leaves yields essential oil with a potent aroma. This oil is used in aromatherapy, cosmetics, and skincare products.

Infused Vinegar and Oils-Curry leaves are infused into vinegar and oils to create aromatic bases for dressings, marinades, and cooking.

Spice Blends and Seasonings-Curry leaves are blended with other spices to create unique seasoning mixes that elevate the flavour profile of various dishes.

REFERENCES

- Abraham, M.R. 2024. Far From Home, the Curry Leaf Tree Thrives. <https://civileats.com/2024/05/08/far-from-home-the-curry-leaf-tree-thrives/>
- Ch'ng, H. Y. 2020. Chapter 1: Background of Curry Leaf. In: Curry Leaf (*Murraya koenigii*): The Story of Potential Miracle Plant. Eds. Siti Nuurul Huda Binti Mohammad Azmin and Huck Ywih Ch'ng . . .
- Grant, B.L. 2023. Curry Leaf Care - Growing Curry Leaf Tree In Your Garden. <https://www.gardeningknowhow.com/edible/herbs/curry/growing-curry-leaf.htm>
- Heritagegarden. 2024. Curry Leaf Tree (*Murraya koenigii*). <http://heritagegarden.uic.edu/curry-leaf-tree-murraya-koenigii>
- Indianculture. 2024. Curry Leaf: The Versatile Wonder Plant. <https://indianculture.gov.in/food-and-culture/spices-herbs/curry-leaf-versatile-wonder-plant>
- Jekkas. 2024. All about herbs: Curry Tree, *Bergera koenigii* (syn *Murraya koenigii*). <https://www.jekkas.com/blogs/jekkas-blog/all-about-herbs-curry-tree-bergera-koenigii>
- Kamat, N., Pearlina, D., Thiagarajan, P. 2015. *Murraya koenigii* (L.) (curry leaf): A traditional Indian plant. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 15(6): 691 - 697
- KSSDB. 2024. Curry leaf: <https://kssdb.karnataka.gov.in/new-page/Curry%20leaf/>
- Kumari, B. 2018. Taxonomy and ethnobotany of *Murraya koenigii* (L.) Spreng: An exotic shrub in Rohilkhand region of Uttar Pradesh. Journal of Medicinal Plants Studies, 6(4):123-125
- Livetoplant . 2023. How to pollinate curry leaf plant: Increase your yield. <https://livetoplant.com/how-to-pollinate-curry-leaf-plant-increase-your-yield/>
- Lofgren, K. 2021. How to Grow Your Own Curry Leaf Tree. <https://gardenspath.com/plants/herbs/grow-curry-leaf/>
- Mandal, U and Mahalik, G. 2021. Chapter 5: A review on *Murraya koenigii* (L.) Spreng. A potent medicinal plant. In: Medico Biowealth of India Vol. III
- Ponraj, A.J., Velmurugan S., Irene Vethamani P., Subramanian A. and Pugalandhi L. 2022. Comparison of Grafted Plants and Seedlings of Curry Leaf (*Murraya koenigii* (L.) Spreng) for Yield and Performance. Biological Forum – An International Journal, 14(2a): 137-140
- Raghu, B.R. 2020d. Diversity and Distribution of Curry Leaf in India. J. Hortl. Sci., 15(1): 1-8
- Raghu, B.R. 2020. Diversity and Distribution of Curry Leaf in India. Journal of Horticultural Sciences, 15(1):1-8
- Raghu, B.R. and Sandeepkumar, G.M. 2023. Curryleaf: importance, conservation and genetic improvement in India. Dr.Y.S.R. Horticultural University. National Conference on Ethnic Vegetables (HYBRID MODE), 27-28 May 2023.
- Raghu, B.R., Aghora, T.S. and Dhananjaya, M.V. 2022a. Curryleaf Improvement in India. Compendium for Winter School on Underutilized Vegetables : Unexplored Treasure Trove for Food, Nritional and Economic Security, 2-22, February 2022.
- Raghu, B.R., Aghora, T.S. and Dhananjaya, M.V. 2020c. Genetic improvement of curry leaf in India: Challenges and future prospects. Indian Horticulture, 65(3): 127-130
- Salgotra, R.K. and Chauhan, B.S. 2023. Genetic Diversity, Conservation, and Utilization of Plant Genetic Resources. Genes (Basel), 14(1): 174.
- Savorysuitcase. 2023. The Symbolism of Curry Leaves in Indian Culture Savory Suitcase! <https://www.savorysuitcase.com/the-origin-and-history-of-curry-leaves/>
- Savorysuitcase. 2023a .Savory Suitcase! <https://www.savorysuitcase.com/the-origin-and-history-of-curry-leaves/>
- Savorysuitcase. 2024b. Savory Suitcase! <https://www.savorysuitcase.com/the-origin-and-history-of-curry-leaves/>
- SGPL. 2021. Growing Curry Leaves Plant | How to Grow Curry Tree. <https://urbanplants.co.in/blogs/news/curry-leaves-plant-complete-growing-guide>
- Shoba, N., Balakrishnan, S., Paramaguru, P. and Vithya, K. 2020. Genetic variability and character association studies in curry leaf *Murraya koenigii*. 2020. Electronic Journal of Plant Breeding, 11(2): 694-697.
- Singh, S., Omre, P.K. and Mohan, S.M. 2014. Curry Leaves (*Murraya koenigii* Linn. Sprengal)- A Mircale Plant. Indian J.Sci.Res., 4 (1): 46-52
- Singha, S., Omreb, P.K. and Mohan, S.M. 2014. Curry Leaves (*Murraya koenigii* Linn. Sprengal)- A Mircale Plant. Indian J.Sci.Res., 4 (1): 46-52
- Suyash. 2024. Growing Curry Leaves Plant | How to Grow Curry Tree. <https://balconygardenweb.com/curry-leaves-plant-complete-growing-guide/>
- Vasanthkumar, S.S., Gowshika, R., Kumaresan, M., Rubika, Pooja, U.K. and Priya, L. 2024. Chapter 4 . Production Technology of Curry Leaf . In: Trends in Vegetable Science ISBN 978-81-19821-41-9. www.researchgate.net/publication/376834302...
- Verma, S. and Rana, T.S. 2013. Genetic relationships among wild and cultivated accessions of curry leaf plant (*Murraya koenigii* (L.) Spreng.), as revealed by DNA fingerprinting methods. Mol Biotechnol., 53(2):139-49.
- Vidhya, D., Indumathi, K., Gurusamy, Paramaguru, K. P. and Geethanjali, S. 2022. Assessment of Genetic Variability for Growth and Yield Traits of Curry Leaf (*Murraya koenigii* L.

Sparg) under Sodic Soil. Biological Forum – An International
Journal 14(2): 912-916

Wikipedia. 2024. Curry tree. From Wikipedia, the free encyclopedia.
https://en.wikipedia.org/wiki/Curry_tree
