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RESEARCH ARTICLE

ORIGIN, TAXONOMY, BOTANICAL DESCRIPTION, GENETICS AND CYTOGENETICS, GENETIC DIVERSITY, BREEDING AND CULTIVATION OF ROSEMARY

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ABSTRACT

Rosemary belongs to the Family: Lamiaceae, Genus: *Rosmarinus*, Species: *Rosmarinus officinalis.* Other scientific names are *Rosmarinus angustifolius* Miller, *Rosmarinus latifolius* Miller, *Rosmarinus laxiflorus* Noë ex Lange and *Salvia rosmarinus* Schleiden. International common names are in English: common rosemary; compass plant, Spanish: romero, French : incensier ; romarin ; romarin officinal ; rosmarin, Chinese: mi die xiang; mi tieh hsiang and Portuguese: rosmaninho. Local common names are in Germany: Garten- Rosmarin; Rosmarin, Haiti: lonmarin; omarin; romarin du pays, India: rasmari; rusmari, Italy: osmarini; ramerino; rosmarino, Japan: mannenrû, Mexico: guixi cicanaca yala-rillaa, quixi cicanaca yalatillaa, Middle East: iklil; iklil el-gabal, Netherlands: rozemarijn, Philippines: dumero; romero; osmiro, Portugal: alecrim, Russian Federation: biberiye; rozmarin, Sweden: rosmarin and Turkey: biberiye. Elizabeth Kent noted in her *Flora Domestica* (1823), "The botanical name of this plant is compounded of two Latin words [*ros marinus*], signifying Sea-dew; and indeed Rosemary thrives best by the sea." Rosemary is a fragrant herb that adds flavor to dishes and beauty to gardens. Easy to grow in India's warm climate, it requires minimal care. Whether for cooking or medicinal uses, rosemary is a versatile addition to any garden. Here's how you can grow and care for it. Rosemary (*Rosmarinus officinalis*) is a hardy, low-maintenance herb that thrives well in home gardens. With its strong aroma and distinct pine-like flavor, it is a favorite choice for enhancing various culinary dishes. Upright varieties of rosemary are particularly useful for both fresh and dried applications. This versatile herb can be grown as an annual, completing its life cycle within a year, or as a perennial, lasting for three or more years under suitable conditionsm. In herb gardens, rosemary is often cultivated alongside thyme, oregano, sage, and lavender, as they share similar growth requirements. Choosing the right variety based on climate, soil conditions, and intended use is key to successful cultivation. Rosemary (*Rosmarinus officinalis*) is an evergreen shrub that is native to the Mediterranean region. It is Relatively easy to grow, making it a good choice for any low-maintenance landscapes or home herb gardens. The small, linear leaves are arranged on opposite sides of the stems. The leaves are rich in essential oils, and their pungent flavor and pine-like scent make them a popular ingredient in foods. The shrub bears small, tubular flowers that can be white ('Albus'), pink ('Roseus'), blue ('Tuscan Blue'), or any shade in between. The flowers are borne on the upper leaf axils (the angle between the stem and the top of the leaves) in spring, summer, and fall. They can be used in salads and as a rosemary-flavored garnish. The growth habit ranges from very upright ('Fastigiatus') to spreading and prostrate. The upright varieties are best for both fresh and dried use. Rosemary is a perennial (completes its life cycle in 3 or more years) in most areas in Texas. If needed, fertilize the soil according to the test results to supplement the nutrition added from compost or organic matter. If the pH is too low, add lime to make the soil more alkaline. Add about 4 inches of organic matter or compost to the soil surface and incorporate it with a pitchfork or a rototiller to a depth of 4 to 6 inches. Raised or slightly mounded beds provide the best drainage for this herb.

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INTRODUCTION

Rosemary belongs to the Family: Lamiaceae, Genus: Rosmarinus, Species: Rosmarinus officinalis (Datiles and Acevedo-Rodríguez, 2014; Sahua and Sahu, 2024; USDA, 2025; Ipmimages, 2025). Other scientific names are *Rosmarinus angustifolius* Miller, *Rosmarinus latifolius* Miller, *Rosmarinus laxiflorus* Noë ex Lange and *Salvia rosmarinus* Schleiden (Datiles and Acevedo-Rodríguez, 2014). International common names are in English: common rosemary; compass plant, Spanish: romero, French : incensier ; romarin ; romarin officinal ; rosmarin, Chinese: mi die xiang; mi tieh hsiang and Portuguese: rosmaninho (Datiles and Acevedo-Rodríguez, 2014). Local common names are in Germany: Garten- Rosmarin; Rosmarin, Haiti: lonmarin; omarin; romarin du pays, India: rasmari; rusmari, Italy: osmarini; ramerino; rosmarino, Japan: mannenrû, Mexico: guixi cicanaca yala-rillaa, quixi cicanaca yalatillaa, Middle East: iklil; iklil el-gabal, Netherlands: rozemarijn, Philippines: dumero; romero; osmiro, Portugal: alecrim, Russian Federation: biberiye; rozmarin, Sweden: rosmarin and Turkey: biberiye (Datiles and Acevedo-

Rodríguez, 2014). Elizabeth Kent noted in her *Flora Domestica* (1823), "The botanical name of this plant is compounded of two Latin words [*ros marinus*], signifying Sea-dew; and indeed Rosemary thrives best by the sea." (Cancio and Vandalsen, 2025). Rosemary is a perennial herb from the mint plant family. It's what we call a woody herb since it develops more and more woody stems as it grows. In moderate climates, rosemary can continue growing throughout the year and even turn into a bush. It's especially great at hanging on in the heat of summer. That means some gardeners have fresh rosemary year round! (Burke, 2024). Rosemary isn't as hardy as other perennials like oregano and thyme. It'll typically only survive winter in zones 7 or up. In zones 7 and 8, it'll die back after a couple of frosts and then return from its roots in the spring. If, however, you live somewhere with temps that drop below 15°F in the winter, you'll either need to treat rosemary as an annual or overwinter it indoors. I've had a lot of success transitioning rosemary indoors each year. Just pot it up and place it near a sunny window, preferably one that's south-facing. It won't produce as many leaves as it does outside, but it'll continue growing moderately until you can move it back out in the spring (Burke, 2024).

Rosemary, as an important antioxidant natural product with many biological activities, has drawn worldwide attention (Sasikumar, 2012). Phenolic diterpenes and phenolic acids, such as CA, carnosol, and rosmarinic acid, which are active chemical components, and the metabolites of rosemary can be used as dietary functional ingredients in chronic diseases such as obesity and diabetes (Sasikumar, 2012). Clear understanding of the chemistry, bioavailability, and efficacy of rosemary constituents in the prevention of obesity and diabetes provide the basis for understanding many of the existing activities and for planning new studies (Sasikumar, 2012). Nevertheless, further studies are needed to better understand the mechanisms of the protective effects of RE and its major components against obesity, diabetes, and diabetes complications (Sasikumar, 2012). Moreover, the beneficial effects of RE on limiting body weight and body fat weight, and the improvement of glucose homeostasis need to be confirmed in humans (Sasikumar, 2012). osemary is native to Mediterranean and Asia, and often used as a seasoning, which contains various phytochemicals, including rosmarinic acid, caffeic acid, and carnosol (Sasikumar, 2012). The studies *in vitro* showed that phenolic compounds in rosemary extracts exhibited antiproliferative effects on cancer cells and increased the sensitivity of colon cancer cells to 5-fluorouracil treatment (Sasikumar, 2012). Polyphenols in rosemary also induced proteomic changes by attenuating aggresome formation and activating autophagy to alleviate cellular stress (Sasikumar, 2012). Rosemary is one of the superior herbs rich in powerful phenolic compounds such as CA, carnosol, RSA, and UA, which exhibits high performance against oxidative reactions in both chemical assays in vitro as well as in real food matrix applications (Sasikumar, 2012). Rosemary extracts/essential oils are powerful antioxidant and antibacterial agent, with a great choice to be used as a natural food additive for preservation (Sasikumar, 2012). At the same time, they could also impart to the flavor profile of the food products and hence could be used as a flavoring agent (Sasikumar, 2012). Besides these two actions of preservation as well as flavoring, they could also contribute to the consumer health-promoting functions, proving their use as a promising plant source for food application (oils/fats, meat and meat products, beverages, and colored food products), especially in functional foods and nutraceutical industry (Sasikumar, 2012). Combination of rosemary extract with other natural ingredients could lead synergistic effect imparting better performance (Sasikumar, 2012). The phenolic compounds also exhibit cognitive as well as immunity enhancement function, especially UA (Sasikumar, 2012). osemary essential oils could be utilized to replace the synthetic food additives in the current market, without compromising its antioxidant capacity (Sasikumar, 2012). Also, in the future with improved regulatory norms, they could widen their use as a natural antioxidant in different food and nutraceutical (Sasikumar, 2012). Rosemary is emerging as an important herb, being a potential source of anticancer molecules, a functional food, a botanical nutraceutical and a functional pesticide (Sasikumar, 2012). Despite the multifaceted importance of the herb, it has yet to receive adequate research attention (Sasikumar, 2012). In many places, it is grown either as a minor herb on marginal lands or still grows wild (Sasikumar, 2012).

R. officinalis is cultivated in tropical and temperate regions around the world (Datiles and Acevedo-Rodríguez, 2014). Outside of cultivation it grows primarily in dry, sandy or rocky soils in a temperate climate characterized by warm summers and mild, dry winters (Datiles and Acevedo-Rodríguez, 2014). It can tolerate maritime exposure and soil types ranging from light (sandy) to medium (loamy), preferring well-drained soil, and can tolerate soils of any pH ranging from acid, neutral and basic (alkaline) soils and even very alkaline soils (Datiles and Acevedo-Rodríguez, 2014). However, the species performs poorly in heavy clay soils and wet, poorly-drained soils in winter are usually fatal (Datiles and Acevedo-Rodríguez, 2014). It has low tolerance for shade and thrives under full sun. The species can grow in premontane and lower montane humid forest climate zones, with reported elevations up to 3500 m (Datiles and Acevedo-Rodríguez, 2014). In the southwestern United States, the species has been recorded growing at elevations below 800 m. In Colombia it has been observed growing between 1500-2500 m, in the Andean regions of Ecuador between 2000-3000 m, in Bolivia between 2500-3500 m, and in the Andean regions of Peru between 3000-3500 m (Datiles and Acevedo-Rodríguez, 2014). The ecological amplitude of rosemary is from the temperate humid zone (mean annual temperature of 6-12°C; mean annual rainfall of 1000-2000 mm) to the subtropical semi-arid to humid zones (18-24°C, 500-2000 mm) (Datiles and Acevedo-Rodríguez, 2014). Its pH tolerance ranges from 4.5-8.3, but preferably 6-7.5 (Datiles and Acevedo-Rodríguez, 2014). In the Mediterranean region, rosemary thrives on calcareous soils, on dry sunny mountain slopes and near the coast where it is frequently exposed to fog and salt spray (Datiles and Acevedo-Rodríguez, 2014). Rosemary can survive in areas with mild winters, but not in localities where the temperature frequently falls below -3°C. Once established rosemary roots deeply and is drought-resistant (Datiles and Acevedo-Rodríguez, 2014). Rosemary is generally recognized as safe when used in medicine or in food. However, large doses over and above those found in food should be avoided during pregnancy because safety of such high doses has not been proven (Datiles and Acevedo-Rodríguez, 2014). Rosemary oil in larger doses is toxic and can lead to intestinal irritation and kidney damage. The monoterpene ketones present in the plant can cause epileptic seizures when taken as the plant or its extract in larger doses or too frequently (Datiles and Acevedo-Rodríguez, 2014). Preparations containing rosemary oil may cause erythema and dermatitis in sensitive people. Allergic contact dermatitis from rosemary has been reported (Datiles and Acevedo-Rodríguez, 2014). Rosemary extract has an anti-implantation effect and plant is a reported abortifacient and also affects the menstrual cycle (Datiles and Acevedo-Rodríguez, 2014). With regard to oral use, rosemary preparations are contraindicated in cases of obstruction of the bile duct, cholangitis, liver disease, gallstones and any other biliary disorders that require medical supervision and advice (Datiles and Acevedo-Rodríguez, 2014). Where symptoms such as articular pain accompanied by swelling of the joint, redness or fever occur medical advice should be sought (Datiles and Acevedo-Rodríguez, 2014). Contact of oil with eyes and mucous membranes should be avoided (Datiles and Acevedo-Rodríguez, 2014).

Rosemary belongs to the mint family (Lamiaceae) together with oregano, thyme, basil and lavender (Datiles and Acevedo-Rodríguez, 2014). It is a fragrant, woody, usually erect, evergreen sun-loving perennial bushy shrub up to 2 m tall and wide, with minty needle-like leaves that measure 2-3 cm (Datiles and Acevedo-Rodríguez, 2014). It is native to the Mediterranean region and grows well in sandy soil or on dry and rocky slopes near the sea in full sun (Datiles and Acevedo-Rodríguez, 2014). Rosemary is drought tolerant, easy to grow and relatively pest resistant (Datiles and Acevedo-Rodríguez, 2014). It is cultivated worldwide because of its aromatic and medicinal properties (Datiles and Acevedo-Rodríguez, 2014). It is one of the most important herbs used for culinary purposes, as well as being used in alternative and herbal medicine, and is an essential element of the Mediterranean diet (Datiles and Acevedo-Rodríguez, 2014). Rosemary

leaves are used as a culinary condiment and the leaves are also used as teas and extracts are used in beverages and as flavourings (Datiles and Acevedo-Rodríguez, 2014). Rosemary and its products are very important because of the many health benefits derived from using this natural ingredient in food (Datiles and Acevedo-Rodríguez, 2014). Published research supports the effectiveness of rosemary as an antioxidant in foods and substantiates the pharmacological benefits of rosemary and rosemary products (Datiles and Acevedo-Rodríguez, 2014). Rosemary extracts are widely used in the food, pharmaceutical and cosmetic industries. It is a vital herb for human health and food safety as it can be used as an effective food preservative (Datiles and Acevedo-Rodríguez, 2014). *R. officinalis* is listed in the Global Compendium of Weeds as "casual alien, cultivation escape, garden thug, naturalised, weed" and is reported to be invasive to Cuba (Datiles and Acevedo-Rodríguez, 2014). The species is of Mediterranean origin but is cultivated pantropically for medicinal, culinary, and ornamental purposes as well as for its essential oils. The species can regenerate by both seeds and cuttings, is tolerant of heat and drought, and thrives in areas with dry, poor, rocky, and sandy soil (Datiles and Acevedo-Rodríguez, 2014). Although previously determined to have 'negligible' potential as a weed according to a 2001 risk assessment prepared for the USDA, risk of introduction for this species has risen since then and is likely to be higher in areas where it is commercially grown, due to its known invasive traits and widespread popularity in cultivation (Datiles and Acevedo-Rodríguez, 2014). *R. officinalis* is native to the Mediterranean region, and was reportedly introduced into China around 220 AD where it is now cultivated (Datiles and Acevedo-Rodríguez, 2014). In England, where the species has been popular since at least Tudor times, Rosemary was probably first introduced by the Romans, but according to tradition it was re-introduced by Queen Philippa of Hainault in the fourteenth century; a manuscript in the library of Trinity College, Cambridge claims that rosemary was unknown in England until the Countess of Hainault sent some to her daughter Queen Philippa (Datiles and Acevedo-Rodríguez, 2014). Date of introduction to the West Indies is uncertain but it has been present there since the early twentieth century (Datiles and Acevedo-Rodríguez, 2014).

Rosemary is a woody evergreen shrub indigenous to the Mediterranean, and now cultivated as an ornamental plant around the globe. Its leaves are in the form of waxy, slightly curved needles. It is fairly salt and drought tolerant. Numerous cultivars exist. Rosemary used in the preparation of antioxidant extracts is sourced from countries where it grows wild (*e.g*., Morocco) or where it is intentionally cultivated (*e.g.,* the United States, France, Spain, Romania) (Rashin Sedighi *et al.,* 2015). Wild rosemary is usually air dried in the shade after collection. Commercially grown rosemary is mechanically dehydrated in heated dryers. U.S. growers who produce antioxidant extracts select rosemary cultivars that are frost resistant and that express high concentrations of the phenolic antioxidant compounds of interest (Rashin Sedighi *et al.,* 2015). Selective breeding in rosemary for enhanced phenolic content is difficult, therefore growers have had to select and settle for the best available cultivars for their purpose. Even so, commercially grown "antioxidant" rosemary generally has higher levels of the important phenolic compounds than that grown in the wild (Rashin Sedighi *et al.,* 2015). Cultivated rosemary is grown from transplanted cuttings, which makes farming somewhat capital intensive compared to operations where direct seeding is an option (Rashin Sedighi *et al.,* 2015). Rosemary can be harvested three to four times per year, and stands of rosemary remain productive for 5 to 7 years (Rashin Sedighi *et al*., 2015). In the United States, the lack of labeled herbicides, the potential for frost damage, and the risk of catastrophic disease spread in a monoclonal population are all circumstances that complicate rosemary cultivation (Rashin Sedighi *et al.,* 2015). The production of phenolic diterpenes in tissue cultures of rosemary. While this technology offers promise, current yields of carnosic acid and carnosol are low (Rashin Sedighi *et al.*, 2015). The concentration of carnosic acid plus carnosol in shoots from green callus was about 2 mg/g of dry weight biomass (Rashin Sedighi *et al*., 2015). Levels in callus culture were about half to a quarter of that in regenerated shoots. These levels are well below those found in cultivated rosemary (Rashin Sedighi *et al.,* 2015).

Rosemary, the memory herb of the mint family, has been used by man since ancient times (Berdahl and McKeague, 2015). Records of the use of rosemary appear in cuneiform on Sumerian stone (Berdahl and McKeague, 2015). The Chinese and Greeks used rosemary as a health conditioner; the Greeks, who wore rosemary wreaths in their hair, also believed that rosemary strengthened the brain and enhanced memory (Berdahl and McKeague, 2015). In Egypt, the herb was buried with the pharaohs. Hungary water, an infusion of rosemary in spirits of wine, is thought to have been first prepared for Queen Izabella of Hungary in 1235 to renovate her paralysed limbs (Berdahl and McKeague, 2015). The word rosemary is derived from the Latin word '*rosmarinus'* meaning 'sea dew'. It was also called '*antos*' by the ancient Greeks, meaning the flower of excellence or 'libanotis' for its smell of incense (Berdahl and McKeague, 2015). There are many myths and much folklore associated with rosemary. It is believed that placing rosemary sprigs under the pillow would ward off evil spirits and nightmares from the sleeper and that the aroma of rosemary would keep old age at bay (Berdahl and McKeague, 2015). During the Middle Ages it was believed that burning rosemary leaves and twigs would scare away evil spirits and disinfect the surroundings; later, it was burned by judges to protect against illness brought in by prisoners (Berdahl and McKeague, 2015). It was also known as a symbol of fidelity and in Europe wedding parties burned rosemary as incense. Rosemary has also been used as a symbol of love and loyalty (Berdahl and McKeague, 2015). As such, in the Middle Ages, rosemary was associated with wedding ceremonies; either the bride would wear a rosemary head piece, the groom and guests would wear a sprig of rosemary or the couple would plant a rosemary bush on their wedding day (Berdahl and McKeague, 2015). In Hungary, ornaments made of rosemary were once used as a symbol of love, intimacy and fidelity of a couple (Berdahl and McKeague, 2015). Some of these myths and beliefs had an underlying scientific logic behind them, as present-day studies reveal (Berdahl and McKeague, 2015). Now it is clear that the essential oil and tannins present in rosemary produce an aromatic smoke with cleansing and purifying properties (Berdahl and McKeague, 2015).

In Ethiopia Rosemary is popular by its local name ''Yetebes Ketel'' which means a leaf used for roasting; the name arises from its widespread use for seasoning meat while roasting (Kassahun *et al.,* 2016). It is also known by an alternative local name as ''Azmerino''. Rosemary is a perennial shrub; if it is managed properly, it can give economical yield from 4 to 7 years (Kassahun *et al.,* 2016). Because of its attractiveness and pleasant aroma rosemary is used as a ground cover and garden plant. It can be planted as a hedge (Kassahun *et al.,* 2016). It is a good source of nectar for bees. The plant is used as an insect repellent and in some cases used as a holiday pot plant at Christmas (Kassahun *et al.,* 2016). Moreover, the fresh and dried leaves of rosemary and its essential oil has several uses. Fresh and dried rosemary leaves, whole or ground, are used as seasonings for soups, stews, sausages, meat, fish, and poultry, In Ethiopia it is used in the preparation of traditional food ingredients like Berebere and Shero (Kassahun *et al.,* 2016). Its essential oil is used as an ingredient in various industries. For instance, the oil is used for meat and other food processing (Kassahun *et al.,* 2016). Rosemary acts on the hair follicles by stimulating hair growth, thus it is used for the preparation of hair foods (Kassahun *et al.,* 2016). It is used in preparation of massage oils and ointments for massage and aromatherapy purposes. It is used for relief from depression and sleepy feelings. It is also used as an ingredient in soaps, creams, candles, deodorants, hair tonics, shampoos, fresheners and organic pesticides (Kassahun *et al.,* 2016). It is an excellent fixative material and contributes a strong, fresh oil odor, which blends well with various other oils odor and serves to mask the unpleasant smells of certain other ingredients (Kassahun *et al.,* 2016).

Topical application is an important administration route for drugs requiring local action on the skin, thereby avoiding their systemic absorption and adverse side effects (de Macedo *et al.,* 2020).

Rosmarinus officinalis L. (syn. *Salvia rosmarinus* Spenn.), popularly known as rosemary, is an aromatic plant with needle-like leaves belonging to the Lamiaceae family (de Macedo *et al.,* 2020). Rosemary has therapeutic properties and has been used in the folk medicine, pharmaceutical, and cosmetics industries, mainly for its antioxidant and anti-inflammatory properties, which are attributed to the presence of carnosol/carnosic and ursolic acids (de Macedo *et al.,* 2020). The therapeutic use of rosemary has been explored for the treatment of inflammatory diseases; however, other uses have been studied, such as wound healing and skin cancer and mycoses treatments, among others (de Macedo *et al.,* 2020). Besides it therapeutic uses, rosemary has potential applications in cosmetic formulations and in the treatment of pathological and non-pathological conditions, such as cellulite, alopecia, ultraviolet damage, and aging (de Macedo *et al.,* 2020). The use of herbal drugs to treat a broad spectrum of diseases and/or to modify non-pathological states has increased worldwide. It is known that the secondary metabolites of plants have therapeutic effects; many have been used in the treatment of different diseases, such as obesity and brain and skin diseases as well as in the treatment of non-pathological states, such as aging (de Macedo *et al.,* 2020). Rosmarinus officinalis L., commonly known as rosemary, belongs to the Lamiaceae family. The genus Rosmarinus has been merged into the genus Salvia in a recent phylogenetic analysis. This means that the Rosmarinus officinalis is no longer the correct name of the species studied (de Macedo *et al.,* 2020). Since the name Salvia officinalis was already occupied when the merger was done, this species needed a new specific epithet in Salvia, so it is now known under the name Salvia Rosmarinus (de Macedo *et al.,* 2020). It is an aromatic plant with needle-like leaves that is cultivated worldwide. Rosemary has therapeutic properties and has been used in folk medicine as an oral preparation to relieve renal colic, dysmenorrhea, and muscle spasms (de Macedo *et al.,* 2020). Rosemary has antifungal, antiviral, antibacterial, anti-inflammatory, antitumor, antithrombotic, antinociceptive, antidepressant, antiulcerogenic, and antioxidant activities (de Macedo *et al.,* 2020). Several medicinal applications for *R. officinalis* have been identified, such as treatment of disorders associated with the nervous, cardiovascular, gastrointestinal, genitourinary, menstrual, hepatic, and reproductive systems and with respiratory and skin conditions (de Macedo *et al.,* 2020). Owing to its diverse properties, rosemary has also been used widely in the food and cosmetics industries. Many biomolecules have been identified to be responsible for the biological effects of rosemary essential oil and crude extract. However, specific compounds causing these effects have rarely been identified; this is due to the synergistic actions of several metabolites present in rosemary (de Macedo *et al.,* 2020). It was also reported a high concentration of flavonoids, polyphenols, and terpenes in **R.** officinalis leaves (de Macedo *et al.,* 2020). Rosemary contains an abundance of secondary metabolites, and their identification by ultra- and high-performance liquid chromatography and gas chromatography has revealed high contents of profile phenolic compounds (diterpenoids and flavonoids) and volatile compounds (de Macedo *et al.,* 2020). The biological activities of secondary metabolites and extracts of R. officinalis were reported in studies investigating various effects such as its antitumor, antioxidant, anti-infectious, anti-inflammatory, and analgesic activities and effects on the central nervous system, endocrine system, disorders such as cardiac remodeling after myocardial infarction, body weight changes, dyslipidemia, cerebral ischemia, hepato-nephrotoxicity, stress, and anxiety (de Macedo *et al.,* 2020).

The anti-inflammatory activity of rosemary has been attributed to the presence of carnosol and carnosic, rosmarinic, ursolic, oleanolic, and micromeric acids, which act synergistically (de Macedo *et al.,* 2020). Specifically, the anti-inflammatory effect was also attributed to the synergic effects of ursolic and micromeric acids present in rosemary extract. The attribution of anti-inflammatory effects of the R. officinalis extract was due to the presence of ursolic, oleanolic, and micromeric acid acting in combination (de Macedo *et al*., 2020). The skin is the largest organ in the human body; sensation, regulation, and protection are among its most critical functions (de Macedo *et al*., 2020). To enhance the permeation of bioactive compounds through the skin, many approaches have been proposed. Of these approaches, nanocarriers including nanoemulsions, lipid nanoparticles, and liposomes have become popular owing to their lipid composition, enhanced biocompatibility, and biodegradability (de Macedo *et al.,* 2020). The release profile of the loaded bioactive compound can be modulated by altering the physicochemical composition of the nanocarrier matrix (de Macedo *et al.,* 2020).

Rosemary is cultivated worldwide due to its diverse uses as spice, preservative and medicine against many illnesses (Asfaw *et al*., 2021). ven though rosemary is widely grown in Ethiopia, the genetic diversity of available germplasms was not assessed (Asfaw *et al.,* 2021). Rosemary is one of the industrially significant crops traded over the world. Its cultivation in many countries depends on locally adapted populations rather than on the use of improved varieties (Zigene *et al.,* 2022). Rosemary is widely known, a Mediterranean herb plant, widely used for various purposes ranging from culinary practices to medicines for centuries (Sahua and Sahu, 2024). The bioactive compounds in rosemary's leaves include essential oils, flavonoids, phenolic acids, and other antioxidants that cause its therapeutic actions (Sahua and Sahu, 2024). This evaluates the medicinal uses of rosemary leaves, from traditional knowledge to modern scientific evidence in terms of their antioxidant, anti-inflammatory, antimicrobial, and cognitive-enhancing effects (Sahua and Sahu, 2024). Rosemary is a herb that has originated from the Mediterranean area. It is used in cooking as well as in medication preparation because of its leaf and its oil (Sahua and Sahu, 2024). Rosemary may promote hair follicle growth by increasing blood flow to the scalp, and rosemary extract can protect the skin against the harmful effects of UV rays (Sahua and Sahu, 2024). People commonly use rosemary for memory, indigestion, fatigue, hair loss, and many other purposes but cannot provide clear scientific evidence to back most of these uses (Sahua and Sahu, 2024).

Rosemary, a mediterranean herb with a rich history of medicinal use, has gained recognition for its wide array of health-promoting properties (Rana and Singh, 2024). This explores the medicinal and therapeutic benefits of rosemary, highlighting its active compounds, including rosmarinic acid, carnosic acid, and essential oils, which contribute to its potent antioxidant, anti-inflammatory, and antimicrobial activities (Rana and Singh, 2024). The herb's neuroprotective effects make it valuable in cognitive enhancement and the potential prevention of neurodegenerative diseases such as Alzheimer's. Rosemary also promotes cardiovascular and digestive health, has potential anticancer properties, and offers skin and respiratory benefits (Rana and Singh, 2024). Widely used in aromatherapy, rosemary has been shown to alleviate stress, improve mood, and enhance mental clarity (Rana and Singh, 2024). While generally safe, precautions are advised for certain individual (Rana and Singh, 2024). Rosemary, a popular aromatic herb, has long been cherished for its medicinal, culinary, and ornamental uses (Rana and Singh, 2024). Native to the Mediterranean region, rosemary is a drought-tolerant, hardy plant, which makes it suitable for cultivation in various climates (Rana and Singh, 2024). As demand for rosemary continues to grow, particularly for its essential oils and health benenfts, understanding its cultivation practices is essential for both small-scale gardeners and commercial farmers (Rana and Singh, 2024). It has been valued for its diverse medicinal properties for centuries. Its use extends from culinary applications to traditional medicine, where it is praised for its ability to promote health and wellness (Rana and Singh, 2024).

Aromatic and medicinal plants have wide applications in traditional and modern food, medicine, and cosmetic systems. They have potential use for various health treatments, food/feed, and cosmetic industries (Banjaw *et al*., 2024). Rosemary is one of the important aromatic and medicinal plants recognized globally. Rosemary is known having different common name from one country to the country. It is perennial plant from the mint family with ever green leaves (Banjaw *et al.,* 2024). Recently its binomial name change reported as *Rosmarinus officinalis* changed to *Salvia rosmarinus* (Banjaw *et al.,* 2024). Rosemary product can be fresh or dry leaf as

well as transformed into oils, extracts, and essences (Banjaw *et al.,* 2024). Rosemary comprises different varieties that can be used for fresh herb, dry herb and for essential oil. Rosemary has economic, social and environmental benefits (Banjaw *et al.,* 2024). Despite of the various constraints, production and marketing of rosemary showed increment from year to Year (Banjaw *et al.,* 2024). Rosemary is an evergreen shrub that is native to the Mediterranean region. It is Relatively easy to grow, making it a good choice for any low-maintenance landscapes or home herb gardens (Masabni and Gu, 2025). The small, linear leaves are arranged on opposite sides of the stems. The leaves are rich in essential oils, and their pungent flavor and pine-like scent make them a popular ingredient in foods (Masabni and Gu, 2025). The shrub bears small, tubular flowers that can be white ('Albus'), pink ('Roseus'), blue ('Tuscan Blue'), or any shade in between. The flowers are borne on the upper leaf axils (the angle between the stem and the top of the leaves) in spring, summer, and fall. They can be used in salads and as a rosemary-flavored garnish (Masabni and Gu, 2025). The growth habit ranges from very upright ('Fastigiatus') to spreading and prostrate ('Prostratus'). The upright varieties are best for both fresh and dried use (Masabni and Gu, 2025). Rosemary is a perennial (completes its life cycle in 3 or more years) in most areas in Texas (Masabni and Gu, 2025). If needed, fertilize the soil according to the test results to supplement the nutrition added from compost or organic matter. If the pH is too low, add lime to make the soil more alkaline (Masabni and Gu, 2025). Add about 4 inches of organic matter or compost to the soil surface and incorporate it with a pitchfork or a rototiller to a depth of 4 to 6 inches. Raised or slightly mounded beds provide the best drainage for this herb (Masabni and Gu, 2025).

Rosemary is an aromatic, perennial evergreen shrub in the mint family (Labiatae) native to the hills along the Mediterranean, Portugal, and northwestern Spain (HORT, 2025). There it grows to a tall shrub 4 to 6 feet high. The plant was also brought to Britain with the Roman armies. The name *Rosmarinus* comes from the Latin *ros maris* or 'dew of the sea', from the dew-like appearance sea spray creates on plants growing close to the water. It was later called Rose of Mary or rosemary in honor of the Virgin Mary. There are various stories or legends to explain this association (HORT, 2025). Even in ancient times, rosemary was associated with remembrance, memory, and fidelity. In Roman times, students wore springs of rosemary in their hair so that their memories would be better. In Shakespeare's Hamlet, Ophelia says 'There's rosemary, that's for remembrance, pray you love, remember.' Rosemary was entwined into the bride's head wreath to encourage couples to remember their wedding vows (HORT, 2025). It was added to wine and used to toast the bride's special wishes. Someone could be made to fall in love merely by being tapped on the finger with a sprig of rosemary (HORT, 2025). It also became a funeral flower, symbolizing the memories of loved ones. It was used in embalming and was placed in tombs as far back as ancient Egypt (HORT, 2025). In Australia today, a sprig is worn on Anzac Day in memory of the dead. The plant has a grayish-green appearance. The thick, leathery leaves resemble needles, with a dark green upper surface and powdery white, hairy underside. The small, pale blue, pink, or white flowers grow in clusters of two or three along branches (HORT, 2025). Rosemary is now widely cultivated outside of Europe. Because it is winter hardy only to about 20°F, rosemary is generally only grown as a potted plant in Wisconsin (HORT, 2025). Plants do best in bright light (full sun) in well-drained soil. The soil should be kept moist, but good drainage is a necessity. Fertilize lightly as excess fertilizer reduces flowering and fragrance. Good air circulation is important to prevent foliar disease (HORT, 2025). Potted plants can be moved outside to a sunny location during the summer, but should be brought inside before first frost. There are two opinions on how to keep your rosemary plant outside in the summer (HORT, 2025). Rosemary is often grown as a topiary. Plants can be shaped or growth controlled by frequent tip-pinching when plants are small. Older plants can be pruned lightly to desired size (HORT, 2025). Cuttings taken from established plants is the best means of propagation. Take 4-6' tip cuttings from a ripe, flower-free shoot in late spring to early summer. Remove the lower leaves, then place the cuttings in a sand/loam/leaf mold mixture or a rooting compound such as vermiculite until the roots have formed (HORT, 2025). Once the root system is established, plant cuttings in pots or outside in a sunny location. To harvest, pick small amounts anytime as needed but do not remove more than 20% of the growth at a time, and avoid cutting into woody parts unless you are shaping the plant, as this will hinder development of the plant (HORT, 2025). For drying, cut sprigs or branches before the plant flowers. Hang bundles upside down in an airy place. When dry, you can leave the sprigs whole or strip the leaves from the stem, and store in an airtight container (HORT, 2025). Rosemary generally has few pest problems, although it can be attacked by aphids, spider mites, mealy bugs or scales. Root rot and botrytis are the most common disease problems. The biggest cause of plant decline and death is overwatering (HORT, 2025). There are many different cultivars of rosemary, including both prostrate and upright forms. Flower color can be blue, pink and white. Certain cultivars are more hardy than others (but none can survive Wisconsin winters) (HORT, 2025).

Rosemary is a fragrant herb that adds flavor to dishes and beauty to gardens. Easy to grow in India's warm climate, it requires minimal care (Shibily, 2025). Whether for cooking or medicinal uses, rosemary is a versatile addition to any garden. Here's how you can grow and care for it (Shibily, 2025). Rosemary (*Rosmarinus officinalis*) is a hardy, low-maintenance herb that thrives well in home gardens. With its strong aroma and distinct pine-like flavor, it is a favorite choice for enhancing various culinary dishes (Shibily, 2025). Upright varieties of rosemary are particularly useful for both fresh and dried applications. This versatile herb can be grown as an annual, completing its life cycle within a year, or as a perennial, lasting for three or more years under suitable conditionsm (Shibily, 2025). In herb gardens, rosemary is often cultivated alongside thyme, oregano, sage, and lavender, as they share similar growth requirements (Shibily, 2025). Choosing the right variety based on climate, soil conditions, and intended use is key to successful cultivation (Shibily, 2025).

Rosemary is an ancient herb and well known for its various medicinal properties (Abd El-Hack *et al.,* 2025). This herb, primarily belonged to Mediterranean regions, now turn out to be well-known and widespread all over the world (Abd El-Hack *et al*., 2025). This evergreen shrub largely grown or cultivated at hilly regions of Morocco, Tunisia, Spain, Portugal, Turkey, Tunisia, Algeria, and India (Abd El-Hack *et al*., 2025). Rosemary's oil and oleoresin have economic importance and used in various food applications (Abd El-Hack *et al.,* 2025). Main bioactives present in Rosemary are carnosic acid (CA), carnosol, rosmarinic acid (RSA), and ursolic acid (UA) (Abd El-Hack *et al*., 2025). Rosemary contains about 1.5%–2.5% of essential oil, which can be recovered by steam distillation or hydrodistillation or microwave distillation or supercritical fluid extraction (Abd El-Hack *et al.,* 2025). This oil is used as a flavoring agent and also used in medicinal and cosmetic formulations. Rosemary extract contains superior natural antioxidants, which is an approved food additive (E392) by the European Food Safety Authority (EFSA) (Abd El-Hack *et al*., 2025). Nowadays, rosemary extracts are used in various applications to replace synthetic antioxidants such as butylated hydroxyl anisole (BHA)—E320, tert-butyl hydroxyl quinone (TBHQ)—E319, and butylated hydroxytoluene (BHT)—E321 (Abd El-Hack *et al.,* 2025). *Salvia rosmarinus*, commonly known as rosemary, is a shrub with fragrant, evergreen, needle-like leaves and white, pink, purple, or blue flowers (Cancio and Vandalsen, 2025). It is a member of the sage family, Lamiaceae (Cancio and Vandalsen, 2025). The species is native to the Mediterranean region, as well as Portugal and Spain (Cancio and Vandalsen, 2025). It has a number of cultivars and its leaves are commonly used as a flavouring (Cancio and Vandalsen, 2025).

ORIGIN AND DISTRIBUTION

R. officinalis is native to the Mediterranean region, from where it has been introduced into all continents. In India, it is reportedly often cultivated in gardens, while it is much rarer in Pakistan. The species is an introduced species in the West Indies and is reported to be invasive to Cuba (Datiles and Acevedo-Rodríguez, 2014). Risk of introduction for *R. officinalis*, at least in the USA, has risen in the last decade.

Previously the risk was considered low; a 2001 USDA pest risk assessment of this species' importation from El Salvador to the USA found its potential as a weed to be negligible as "it has not been reported to have weedy characteristics" but it has since been listed in the Global Compendium of Weeds as "casual alien, cultivation escape, garden thug, naturalised, weed" and is known to be invasive to Cuba. The species is distributed well beyond its native Mediterranean range as it is cultivated around the world for medicinal, culinary, and ornamental purposes as well as for its essential oils. It is capable of regenerating by both seeds and cuttings, tolerates heat and drought, and thrives in areas with dry, poor, rocky, and sandy soils. Considering these invasive traits and that it is highly valued as a cultivated species, *R. officinalis* will have many opportunities to escape to non-native ecosystems and may pose a higher risk of introduction near areas where it is cultivated (Datiles and Acevedo-Rodríguez, 2014). *R. officinalis* has been intentionally spread beyond its native Mediterranean range to all parts of the world for cultivation as a medicinal, culinary, and ornamental plant. It has been accidentally introduced as it is a known cultivation escape. The species is capable of regenerating by both seeds and cuttings, and can thus spread through garden waste or plant parts sold for medicinal and culinary use. The species can also be spread by vehicles used in agricultural settings where the species is commercially grown (Datiles and Acevedo-Rodríguez, 2014). *R. officinalis* originated in the Mediterranean region with coastal climate, and can tolerate heat, drought, and poor, dry, sandy, and rocky soil types. The species is cultivated around the world in both urban and rural gardens and agricultural settings. It also occurs in disturbed areas in Peru, while in Colombia, it occurs in premontane and lower montane humid forest habitats, and in Bolivia it occurs in dry valleys (Datiles and Acevedo-Rodríguez, 2014). Rosemary compass plant, Family Lamiaceae, is native to the Mediterranean – from Spain to the Balkans and into North Africa. At present, it is widely cultivated in Spain, Morocco, Tunisia, France, Algeria, Portugal and China and, to a limited extent, in India in the Nilgiris and Bangalore. Rosemary chemotypes with distinct morphological characters and oil quality occur in Italy (Berdahl and McKeague, 2015).

It is native to the Mediterranean region, rosemary has naturalized throughout much of Europe and is grown widely in gardens in warm climates (Sahua and Sahu, 2024). Rosemary with diverse genetic diversity was believed to be originated from the western Mediterranean basin and has been cultivated since ancient times as landscape plant as well as pot crop for ornamental purposes, leaves and essential oil products. In their demographic expansion study indicated different routes of rosemary migration such as a northern route expanding along the northern side of the Mediterranean, two southern routes, one from west to east through North Africa and reaching Cyrenaica, and a second to the south-west of the Iberian Peninsula, from where it came back to the south–central areas (Banjaw *et al*., 2024). It is native to the Mediterranean region, as well as Portugal and northwestern Spain. It was first mentioned on cuneiform stone tablets as early as 5000 BCE. The herb was naturalized in China as early as 220 CE, during the late Han dynasty. Rosemary came to England at an unknown date, though it is likely that the Romans brought it when they invaded Britain in 43 CE. Even so, there are no viable records containing rosemary in Britain until the 8th century CE. This mention was in a document which was later credited to Charlemagne, who promoted the general usage of herbs and ordered rosemary specifically to be grown in monastic gardens and farms. There are no records of rosemary being properly naturalized in Britain until 1338, when cuttings were sent to Queen Philippa by her mother, Countess Joan of Hainault. It was then planted in the garden of the old palace of Westminster. Since then, rosemary can be found in most English herbal texts. Rosemary finally arrived in the Americas with early European settlers in the beginning of the 17th century, and was soon spread to South America and distributed globally. It is reasonably hardy in cool climates. Special cultivars like 'Arp' can withstand winter temperatures down to about −20 °C. It can withstand droughts, surviving a severe lack of water for lengthy periods. It is considered a potentially invasive species and its seeds are often difficult to start, with a low germination rate (Cancio and Vandalsen, 2025).

TAXONOMY

The Lamiacae family, or mint family, is a family of herbs, shrubs and trees comprising about 200 genera and 3200 species, many with a long history of medicinal and food use. This family includes some of the most well-known herbs containing essential oils, including lavender, sage, basil, mint and oregano. Many Lamiaceae species have square stems (although square stems are also found in other families), aromatic aerial parts when crushed, simple opposite leaves, and two-lipped flowers. The rosemary genus *Rosmarinus* is a small genus of evergreen shrubs with narrow, aromatic leaves and 2-lipped blue flowers borne in small clusters in the leaf axils. The genus name derives from the Greek *ros* and *marinus*, 'dew of the sea', referring to its native seaside Mediterranean origin. *Rosmarinus officinalis* is the type species of the genus, as well as the most well-known rosemary species. It is a bushy, evergreen perennial shrub native to the Mediterranean and cultivated around the world as a medicinal, ornamental, culinary, and essential oil-bearing plant. Common names for *R. officinalis* relate the species to various myths and folklore, as the plant has been known and used in many cultures since antiquity. In Portugal, for example, the plant was called 'alecrirn' a word derived from the Scandinavian 'ellegren', meaning 'elfin-plant', as folklore associated the plant with elves, and in Sicilian tales it was said that baby fairies slept in the rosemary flowers. In Spain a common name for the species, 'romero', is interpreted as 'pilgrim's flower', in reference to a traditional tale that the Virgin Mary rested under a rosemary bush during the flight to Egypt. Rosemary is very variable in habit (erect to creeping), size and colour of leaves and flowers and composition of the essential oil. This variability has led to recognition of four species by some; others distinguish one species with many varieties and forms (Datiles and Acevedo-Rodríguez, 2014).

Rosemary is one of the versatile aromatic plants from the Lamiaceae family. It is popular herb in many countries for its leaf and essential oil yield. Rosemary has various common names like asmerino in Ethiopia, romero in Spain, rosmaninho in Portugal, mehendi in India, rosmarin in German, romarin in French, and mi die xiang in China. Despite different names given to rosemary from different countries in the world, the plant was known by one scientific name (Binomial name). The use of binomial system was initiated during 1700s by Swedish naturalist Carl Linnaeus and the binomial name of rosemary herb was *rosmarinus officinalis* so far. The name *Rosmarinus officinalis* was used among growers, academic and research institutes and scientists all over the globe used the name regardless of the various common names of the popular rosemary herb. The genus name, *Rosmarinus*, comes from the Latin words *ros* (dew) and *marinus* (sea) which born a name called dew of the sea, in probable reference to the ability of this plant to thrive well in coastal areas (sea cliffs) and exposure to ocean mists. Various common names for rosemary herb could be due to variation of languages from place to place. In the contrary, binomial name of a living thing remain constant unless renamed based on new findings which was done for rosemary herb recently. Based on DNA analysis the common genus name of rosemary since 18 century becomes the species name of the herb so that the name *Rosmarinus officinalis* has become a synonym of the actual name *Salvia rosmarinus* (Banjaw *et al.,* 2024). *Salvia rosmarinus* is now considered one of many hundreds of species in the genus *Salvia*. Formerly it was placed in a much smaller genus, *Rosmarinus*, which contained only two to four species including *Rosmarinus officinalis,* which is now considered a synonym. Both the original and current genus names of the species were applied by the 18th-century naturalist and founding taxonomist Carl Linnaeus (Cancio and Vandalsen, 2025).

Botanical Description

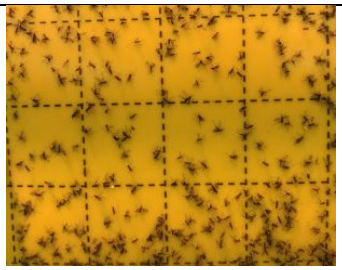
Rosemary is an evergreen, usually erect, bushy shrub up to 2 m tall and wide. Stem indistinctly quadrangular, finely grey pubescent. Leaves opposite, tufted on the branches, sessile to short petiolate; blade linear, 1-5 cm x 1-2 mm, base attenuate, margin entire but revolute, apex obtuse, leathery, dark glossy sea-green and subglabrous above, white-felted tomentose beneath, aromatically fragrant when crushed. Inflorescence racemose, axillary, 5- to 10-flowered, 0.5-2.5

cm long, terminating short lateral branches; pedicel 2-5 mm long; calyx campanulate, 2-lipped, 5-6 mm long, densely stellate tomentose, upper lip small and 3-dentate, lower lip 2-lobed; corolla tubular, 2-lipped,10-13 mm long, pale blue or blue (seldom white), upper lip erect or recurved, 2-lobed, ovate, about 4 mm long, lower lip 3-lobed, about 7 mm long, with large concave middle lobe; 2 anterior stamens perfect, 7-8 mm long, ascending under the base of the upper lip, 2 posterior stamens reduced to hardly visible staminodes; pistil with deeply 4-partite ovary, style incurved, 1.5 cm long ending into 2 short, unequal branches with stigma. Fruit composed of 4 subglobose to obovoid nutlets, about 2 mm long, glabrous and smooth (Datiles and Acevedo-Rodríguez, 2014).

Rosemary is a dense, evergreen, hardy perennial aromatic herb of 60–200 cm in height with small (2–4 cm) pointed, leaves. The upper surface of the leaf is dark green or blue, while the underside of the leaf is white; the leaves are resinous. Branches are rigid with fissured bark and stems brown, square and woody. Flowers are whitish, blue or purple in cymose inflorescence. The leaves, flowering tops and twigs yield an essential oil and oleoresin valued in recipes, traditional medicine, modern medicine and aromatherapy as well as in the perfume and flavour industries. Although it is generally *R. officinalis* that is used for oil extraction, in Morocco *R. eriocalyx* is also used for extracting essential oil. The annual global oil production is 200–300 metric tonnes.

Seeds

Seeds



Seeds

Seedlings

Seedlings

Seedlings

The needle-like leaves of rosemary

Rosemary plant

Rosemary leaves

Rosemary flower

Rosemary flower

Rosemary flower

Rosemary flower

Rosemary flower

Dried leaves


Drying


Threshing


Field view


Essential oil

Rosemary oil


Rosemary oil

Fig. 1. Botanical Description

Many different varieties and cultivars are grown, each varying in flower colour (blue/pink/white), plant habit (erect/spreading), leaf colour (olive/blue/green), size of leaves (Rashin Sedighi *et al.,* 2015). Rosemary is a dense, evergreen, hardy perennial aromatic herb of 60–200 cm in height with small (2–4 cm) pointed, leaves. The upper surface of the leaf is dark green or blue, while the underside of the leaf is white; the leaves are resinous. Branches are rigid with fissured bark and stems brown, square and woody. Flowers are whitish, blue or purple in cymose inflorescence. The leaves, flowering tops and twigs yield an essential oil and oleoresin valued in recipes, traditional medicine, modern medicine and aromatherapy as well as in the perfume and flavour industries. Although it is generally *R. officinalis* that is used for oil extraction, in Morocco *R. eriocalyx* is also used for extracting essential oil. The annual global oil production is 200–300 metric tonnes. Many different varieties and cultivars are grown, each varying in flower colour (blue/pink/white), plant habit (erect/spreading), leaf colour (olive/blue/green), size of leaves (Berdahl and McKeague, 2015). Rosemary plant is a woody aromatic perennial shrub with fragrant evergreen needle-like leaves. It belongs to the mint family, Lamiaceae. It grows upward (erect) and can extent up to a height of 2 m. The leaves are evergreen, 2-4 cm long and 2-5 mm broad, green above, and white below with dense short woolly hairs. Different rosemary varieties have different leaf sizes, branch growth habit, and flower color (white, pink, purple, or blue). Botanical variation in rosemary plant varieties resulted in the variation of rosemary herbal, oil yield, and chemical compounds (Banjaw *et al*., 2024). Rosemary has a fibrous root system. It forms an aromatic evergreen shrub with leaves similar to *Tsuga* needles. Forms range from upright to trailing; the upright forms can reach between 1.2–1.8 metres tall. The leaves are evergreen, 2–4 cm long and 2–5 mm broad, green above, and white below, with dense, short, woolly hair. The plant flowers in spring and summer in temperate climates, but the plants can be in constant bloom in warm climates; flowers are white, pink, purple or deep blue. The branches are dotted with groups of 2 to 3 flowers down its length. Rosemary also has a tendency to flower outside its normal flowering season; it has been known to flower as late as early December, and as early as mid-February (in the Northern Hemisphere). The plant can live as long as 35 years (Cancio and Vandalsen, 2025). (Fig. 1).

Genetics and Cytogenetics

Gametophytic count = 10, 12; sporophytic count = 24 (IPCN Chromosome Reports, 2014) (Datiles and Acevedo-Rodríguez, 2014). The chromosome number of rosemary (Salvia rosmarinus, formerly Rosmarinus officinalis) is 2n = 24. This means that rosemary plants have 24 chromosomes in their somatic (non-sex) cells, with 12 chromosomes inherited from each parent (AI Overview, 2025).

GENETIC DIVERSITY

The distribution of genetic variability in rosemary, a strictly Mediterranean species of reputed Plio-Quaternary origin for which the diversification centre is hypothesized to be located in the western part of the Mediterranean basin, was investigated across the species range by using plastid microsatellites [plastid simple sequence repeat (cpSSR)] markers. Seven out of the 17 primer pairs screened were polymorphic, with up to four alleles, yielding a total of 17 size variants combined into ten haplotypes. A permutation test to investigate for geographical structure showed no significant differences between R_{ST} and G_{ST}, indicating that the species lacks geographical structure. Low correlation between genetic and geographical distances was shown by the Mantel test. Bayesian analysis identified two coancestry groups of populations. The distribution of genetic diversity supports the hypothesized origin in the western Mediterranean basin, and with the demographic expansion test indicates three different routes of migration: a northern route expanding along the northern side of the Mediterranean and two southern routes, one from west to east through North Africa and reaching Cyrenaica, and a second to the south-west of the Iberian Peninsula, from where it came back to the south–central areas (Mateu-Andrés *et al.,* 2013).

Genetic diversity of 45 rosemary accessions collected from different parts of Ethiopia was analyzed using 12 simple sequence repeat markers. A total of 189 alleles were detected, and the number of alleles per marker (Na) ranged from 7 to 27 with an average of 15.75. About 56.6% of the alleles were rare (frequency < 0.05), whereas 23.8% and 19.6% were intermediate (frequency 0.05–0.5) and abundant (frequency > 0.5), respectively. Polymorphic information content per marker ranged from 0.74 to 0.94, with an average value of 0.87. The result depicted over all polymorphism of 92.6%, indicating the existence of high genetic variability among the accessions. The average values of expected (H_E) and observed (H_O) heterozygosities were 0.65 and 0.35, respectively. The average H_O was lower than H_E, showed heterozygote deficiency due to restricted cross-fertilization. Analysis of molecular variance revealed that within populations variations contributed more to the genetic diversity than between population variations. Unweighted Neighbor Joining based phylogenetic analysis, Principal Coordinate analysis and STRUCTURE analysis showed admixture of the populations,

confirming that the sample groupings did not strictly follow the geographic origin of the accessions. Therefore, improvement program of the crop should focus on actual diversity, not on area of growing (Asfaw *et al.,* 2021).

Collection and characterization of the local populations could contribute to their conservation and selection of desirable traits. Therefore, this study was undertaken to estimate the diversity of 45 rosemary accessions collected from different parts of Ethiopia using qualitative morphological traits. The frequency distribution of characters reflected the polymorphism of the studied characters, and a total of 39 phenotypic classes were observed. Shannon-weaver diversity indices estimated across accessions ranged from 0.43 to 0.99 with a mean value of 0.79, demonstrating the existence of adequate phenotypic diversity among the accessions. Estimates of diversity indices within and among growing regions revealed that intra-region diversity (0.57) exceeds inter-region diversity (0.43). Cluster analysis classified the accessions into six major clusters regardless of the accessions' geographical origin. This was consistent with the estimated within and among growing regions diversity indices. The results clearly showed the presence of considerable levels of phenotypic diversity that could be exploited as a source of a valuable gene pool for future breeding programs (Zigene *et al.,* 2022).

In the present study, 24 clones were used to assess the chemical and inter simple sequence repeat (ISSR) based genetic diversity. The analysis of variance based on chemical constituents showed significant differences among the clones for chemical components, and 24 progenies were grouped into four chemotypes groups viz.,1,8-cineole type (18.59–35.19%), verbenone type (2.71–15.70%), camphor type (3.12–29.86%), and α-pinene type (4.33–27.71%). Thirteen ISSR primers produced 6.51 average polymorphic bands with 58.26% percent polymorphism. The cluster analysis, using the unweighted pair group method with Arithmetic mean (UPGMA) tree method, classified the 24 rosemary progenies into three major clusters at a coefficient of 0.24. Even though the chemotype and molecular grouping were different, the study's results emphasize that evaluating both chemical and genetic diversity is crucial for successful rosemary cultivation and breeding efforts. The findings contribute valuable insights for further research and development in the field of rosemary cultivation and utilization in India (Swamy Gowda *et al*., 2024).

BREEDING

Propagation

The Step by Step to Propagating: When it comes to propagating rosemary, you can either keep your cuttings in some fresh water until they develop roots or plant them directly in some sand. Rooting a cutting in water typically produces roots faster, while planting cuttings in sand often results in stronger plants when they're transferred to soil. You choose the method that best works for you (Gardenary, 2025).

Gather Rosemary Cuttings: You can either buy organic sprigs of rosemary from the grocery store or take cuttings from an existing plant. To harvest your own cuttings, it's important to know that there are two types of wood on rosemary plants: soft and hard. The tips of each branch are soft, meaning you could bend each tip without it breaking. The hard wood is older and down at the bottom of the branch, and if you tried to bend those stems, they'd snap. For propagation, you'll need a soft cutting about 4 to 6 inches long. If you're harvesting from a plant, look for the place where the stem transitions from soft to hard wood (Gardenary, 2025).

Prepare Rosemary Cuttings: Take your clean pair of pruners or sharp scissors and cut the bottom of the stem at a 45 degree angle. This opens up the capillaries so that the plant can better absorb water and grow new roots. Strip the leaves from the bottom third of the pruned stems all the way down to the end of the trimming so that there are a couple of inches of bare rosemary stem. Take the leaves you've stripped and either dry them or use them right away in your kitchen (Gardenary, 2025).

Put Rosemary Cuttings: If you're going to keep your cuttings in water until roots form, make sure that the cup is small enough to keep the cuttings upright and that only the stem, not the leaves, touches water. I like to clean out an old spice shaker with large holes in the cap that can hold the cuttings in place. Fill your container with fresh water. If you're planting your cuttings straight away, make sure that your pot has good drainage holes. I like to use terra cotta pots. Fill the pot with coarse sand like paver sand (not play sand), which is available at any hardware store. Sand is a great medium for rooting herbs because it shifts easily to accommodate growing roots and doesn't hold onto too much moisture. While you don't need to use rooting hormone for herbs, it's a great idea to dip the angled tips of your cuttings in some cinnamon to prevent the stem from rotting as it's trying to form roots. Moisten your sand and make a little hole in the middle with the end of a pencil or a dibber, if you have one. Place the cutting into the hole, being careful not to bend the tip. All of the leaves should be above the sand. Support the cutting with sand to keep it upright as it starts to produce roots. You can plant several cuttings in the same container (Gardenary, 2025).

Tend Rosemary Cuttings : If your cuttings are in water, pour out the old water and fill with fresh water every couple of days. Keep your container in a semi-shaded place. If your cuttings are potted up, make sure the sand stays moist but not soaking wet. Put your cuttings in a spot where they'll receive bright but indirect light. The water method should start to produce roots within a couple of weeks. Transfer your cuttings to a small pot filled with soil and compost once roots have formed. Again, use a pencil or dibber to make a big enough hole that the roots of the cutting aren't disturbed when planting. Though it does take longer, a potted cutting should form really healthy roots within four to six weeks. Once you see new growth, you can transfer your plants to their own individual pots filled with soil or your kitchen garden. Make sure you let the soil of your rosemary plant dry out before you come back and water again. Rosemary doesn't like to be overwatered (Gardenary, 2025). It's amazing to watch tiny cuttings grow and flourish into brand new rosemary plants. You can literally grow rosemary year after year and never run out by continuously propagating your plants. You can even gift rosemary babies to your friends and neighbors for the holidays. If they keep their rosemary in a sunny window for the winter, they'll have a mature plant by the spring. Thanks for helping me bring back the kitchen garden, one rosemary plant at a time (Gardenary, 2025).

Propagation method

By Seeds: While rosemary can be grown from seeds, this method is often slow and has a low germination rate. Seedlings may take up to three weeks to germinate and often require optimal conditions for successful growth. Here's how to propagate rosemary from seeds:

- Sow seeds in a well-drained seed-starting mix.
- Keep the seed tray in a warm, sunny location with temperatures between 18°C and 24°C.
- Mist the soil lightly to keep it moist but not waterlogged.
- Transplant seedlings when they are large enough to handle, typically when they have at least two sets of true leaves. (Rana and Singh, 2024).

By Cuttings: Propagation by cuttings is the most reliable and preferred method for growing rosemary. It ensures faster growth and maintains the characteristics of the parent plant. To propagate rosemary from cuttings:

- Select healthy, non-Áowerings tems about 10-15 cm (4-6 inches) long.
- Remove the lower leaves from the stem, leaving 4-6 leaves at the top.
- Dip the cut end in rooting hormone (optional) and place it in a well-draining soil mix or water.
- Keep the cutting in indirect light and maintain consistent moisture.
- Once roots form (in about 4-6 weeks), transplant the cutting to its final location (Rana and Singh, 2024).

***By Layering**:* Another reliable method of propagating rosemary is through layering. This technique involves bending a low-growing stem and pinning it to the soil while still attached to the mother plant. The pinned section will eventually develop roots, after which it can be separated and transplanted (Rana and Singh, 2024).

Propagation: Rosemary is commonly propagated by cuttings, division or by air layering. Seeds are sometimes used, but they are produced only under very favourable growing conditions and often only 10-20% of the seeds germinate. Transplanting to the field is done at a spacing of 45 cm between plants in rows 1.2 m apart. It is also common to produce rosemary in containers in greenhouses. Rosemary is commonly propagated by cuttings, division or by air layering. Seeds are sometimes used, but they are produced only under very favourable growing conditions and often only 10-20% of the seeds germinate (Datiles and Acevedo-Rodríguez, 2014). Rosemary can be propagated by seeds or by using vegetative parts like layering and cutting. Rosemary seeds have problem of viability as well as problem of getting true-to type material and needs further improvement investigations. However, top part 10-15cm rosemary cuttings used for seedling preparation from disease free mother plant not more than one year old. The bottom two thirds of the cuttings are stripped from leaves and inserted in a proper growing medium. The cuttings can be prepared in green house and transplanted to the main field after 60-90 days. Rooting hormones will assist in root formation within 2 to 4 weeks. Rosemary stems with flowering, old woody and very young plants are not advised for cutting preparation. Moreover, mass propagation by tissue culture technology is also alternative means of rosemary propagation (Banjaw et al., 2024). There aren't very many things in this world that you can cut up and tear apart, only to have it grow into something new. That's the magic of plants. Through propagation, we can turn one plant into a couple plants, turn those plants into more plants, and eventually end up with hundreds. I fell in love with rosemary long before I ever even gardened. I was in grand school and not in a very great place emotionally. There was a huge rosemary bush on campus, and one day, I accidentally bumped into it on my way to class. The smell instantly comforted me. I started impulsively grabbing branches from the plant as I was moving between classes and carrying them with me. Now, I know that clinical studies have linked the smell of rosemary to relieving anxiety and even helping with depression. Little wonder that rosemary was the first thing I planted in my garden in Virginia and that I've grown it in every garden since (Gardenary, 2025).

Genetic Resources: Rosemary germplasm collections are available in most Mediterranean countries, for example, at the Portuguese Germplasm Bank, Braga, Portugal (20 accessions) and at the gene bank of the Institute for Plant Genetics and Crop Plant Research, Gatersleben, Germany (four accessions) (Datiles and Acevedo-Rodríguez, 2014).

Cultivars: There are a number of cultivars available, but for commercial purposes the following are the most important: 'Camphor-borneol' grown in Spain, '1,8-Cineole' grown in Tunisia and 'Verbenone' grown in France. Other notable cultivars are 'Albus' (white flowers), 'Collingwood Ingram' (short, spreading), 'Tuscan Blue' (dark blue-violet flowers), 'Lockwood de Forest' and 'Prostratus' (low-growing and making excellent ground covers), 'Roseus' (erect type, highly fragrant). A frost-resistant rosemary cultivar has been selected in Hungary. The whole plant is aromatic; the cultivar 'Corsican Blue' is more aromatic than others. In North America it is being attemped to obtain frost-tolerant rosemary cultivars. In some places 'Arp' and 'Hill Hardy', two cold-tolerant cultivars, survive severe winters (with protection of mulch) and in others they do not (Datiles and Acevedo-Rodríguez, 2014). There are two main forms of rosemary: arp rosemary (also known as upright rosemary) and trailing rosemary (aka prostrate rosemary). I love the look of trailing rosemary spilling elegantly over the side of a raised bed, but many of my clients prefer growing arp rosemary. The leaves get a little bigger and are, therefore, easier to use in the kitchen (Burke, 2024).

Cultivars (Masabni and Gu, 2025).

- 'Albus'
- 'Arp'
- 'Blue Boy'
- 'Dancing Waters'
- 'Golden Rain'
- 'Pine Scented'
- 'Prostratus'
- 'Roseus'
- 'Spice Islands'

The best variety for cooking is 'Pine Scented' because of its excellent flavor and soft leaves. Also used in cooking are 'Blue Boy,' 'Spice Islands,' and 'White' rosemary. The varieties used more often as landscape plants are 'Arp,' 'Dancing Waters,' 'Golden Rain,' 'Pink,' and 'White'.

Cultivars (Cancio and Vandalsen, 2025).

- 'Albus' – white flowers
- 'Arp' – leaves light green, lemon-scented and especially cold-hardy
- 'Aureus' – leaves speckled yellow
- 'Benenden Blue' – leaves narrow, dark green
- 'Blue Boy' – dwarf, small leaves
- 'Blue Rain' – pink flowers
- 'Golden Rain' – leaves green, with yellow streaks
- 'Gold Dust' – dark green leaves, with golden streaks but stronger than 'Golden Rain'
- 'Haifa' – low and small, white flowers
- 'Irene' – low and lax, trailing, intense blue flowers
- 'Lockwood de Forest' – procumbent selection from 'Tuscan Blue'
- 'Ken Taylor' – shrubby
- 'Majorica Pink' – pink flowers
- 'Miss Jessopp's Upright' – distinctive tall fastigiate form, with wider leaves.
- 'Pinkie' – pink flowers
- 'Prostratus' – lower groundcover
- 'Pyramidalis' (or 'Erectus') – fastigiate form, pale blue flowers
- 'Remembrance' (or 'Gallipoli') – taken from the Gallipoli Peninsula
- 'Roseus' – pink flowers
- 'Salem' – pale blue flowers, cold-hardy similar to 'Arp'
- 'Severn Sea' – spreading, low-growing, with arching branches, flowers deep violet
- 'Sudbury Blue' – blue flowers
- 'Tuscan Blue' – traditional robust upright form
- 'Wilma's Gold' – yellow leaves
- The following cultivars have gained the Royal Horticultural Society's Award of Garden Merit:
- 'Benenden Blue'
- 'Miss Jessopp's Upright'
- 'Severn Sea'[31]
- 'Sissinghurst Blue'

Cultivars (HORT, 2025).

'Albus' or 'Albiflorus' (White-flowered rosemary) – Upright, dense growth; white flowers; dynamic bloomer.

- 'Arp' – Upright growth; pungent but without a strong and sharp scent; hardy to 10°F.
- 'Collingwood Ingram' (Wood rosemary) – Upright growth; dark blue flowers; short and plump leaves; looser appearance with gracefully pendulous branches.
- 'Creeping' – Prostrate growth; deep blue flowers; long branches that twist and curl and recurve; blooms almost continuously.

- 'Lockwood de Forest' or ' Lockwoodii' or 'Foresteri' or 'Santa Barbara' or 'Protstratus' or 'Trailing' (Trailing Rosemary) – Prostrate growth; light blue flowers; arching woody stems.
- 'Majorca Pink' or 'Majorca' or 'Roseus' or 'Roseus-Cozart' (Pink Rosemary) – Upright growth; pink to lavender flowers; produces long branches that twist around the plant and then cascade; blooms sparsely but almost continuously; hardy to 15°F.
- 'Officinalis' (Upright Rosemary) – Upright growth; blue-violet flowers.
- 'Tuscan Blue' (Tuscan Blue Rosemary) – Upright growth; deep blue-violet flowers; reddish stems; fast grower; mild fragrance; hardy to 15°F.

Varieties Suitable For India (Shibily, 2025).

Arp, Creeping, Pine Scented, Upright, Dancing Waters, Spice Islands, Blue Boy, Golden Rain. Pink. Pine Scented rosemary is ideal for cooking in India due to its excellent flavor and soft leaves. Blue Boy, Spice Islands, and White rosemary are also commonly used in cooking. On the other hand, Arp, Dancing Waters, Golden Rain, Pink, and White varieties are more frequently used as landscape plants in Indian gardens (Shibily, 2025).

Variety- Ooty-1 (Mahr, 2025).

Ooty (R, M) 1 rosemary variety of horticultural research station maintained utakai was selected from five kinds of rosemary seedlings.

- The rapid growth of the plants of this variety (an average of 62 cm height) was not reached.
- The length of the leaves of this variety, roller, will be matankiyat inward.
- It gives the green leaf yield of 13 tons per year of this variety. The potential yield of 46 per cent is higher than the local irakattaik.
- The leaves are dark green, thick and is willing to skin. The green and dry leaves is ideal for cooking with good flavor.
- Harvested 215 days after planting seedlings in the first. The year can be harvested three times at intervals of 3 to 4 months.
- disease, the white fly and aphid resistant.
- This leaves a large number of content (0.9 per cent) higher levels of lactose content in the leaves (60.66 mg-kg) and protein (24.90 mikiki) found.
- In the mountainous areas of J% - J% Lie and September - October months of the rainfed crop can be planted.
- In mountainous areas (up to 900 m above sea level) to the optimal crop.
- The variety of the climate, such as drought and frost tolerant and grows.

Uses: *R. officinalis* is used as a food additive and medicine, and is also grown for its essential oils and as a bee plant for honey production. It is cultivated for its aromatic oils in the Mediterranean, and in India it is reputedly quite widely cultivated in gardens, while in Pakistan it is also apparently used as a hedge plant. The species is known to be sedative, carminative, sudorific, cardiac stimulant, anti-inflammatory, anti-rheumatic, diuretic, digestive, antiseptic, and anti-spasmodic. Antifungal and pesticidal effects of the essential oil of rosemary have been widely investigated. It wsa reported effectiveness of the essential oil used as a fumigant against *Sitophilus oryzae* and *Oryzaephilus surinamensis*, and record inhibition of enzyme activity in the test insects. "The fresh or dried leaves are excellent flavouring agents in vegetables, meat (particularly lamb, veal and roasted chicken), sauces, stews, herbal butters, cream soups, fruit salads, jams, biscuits and bread. The dry leaves are also used in crushed or powder form, primarily in food preparations (Datiles and Acevedo-Rodríguez, 2014).

Rosemary oil, distilled from the flowering tops and leaves, is used to season processed foods, but for the most part it is employed in perfumes, in scenting soaps, detergents, household sprays and other related technical products. It finds application in denaturing alcohol and is popular in aromatherapy. In the USA the regulatory status 'generally recognized as safe' has been accorded to rosemary, rosemary oil, and rosemary oleoresin. The maximum permitted level of rosemary oil in food products is about 0.003%. Rosemary oleoresin is used in the food industry as a natural antioxidant, for instance in cooked meat products. In traditional medicine, rosemary is thought to fortify the brain and refresh the memory. Flowering tops and leaves are considered carminative, diaphoretic, diuretic, aperient, emmenagogue, stimulant, stomachic and astringent. Rosemary also serves as a household remedy for headaches, bruises, colds, nervous tension, asthma, baldness and sore throat. In the Philippines, an infusion of the leaves is used as an eyewash for slight catarrhal conjunctivitis, as vapour baths for rheumatism, paralysis and incipient catarrhs, and to bathe women in puerperal state. Rosemary leaves are therapeutically allowed internally for dyspeptic complaints, and externally for rheumatic diseases and circulatory problems. Rosemary is very popular as an ornamental plant used as a ground cover, hedge or shrub and is even transformed by hobbyists into bonsai or planted in hanging baskets. The leaves and flowers can be carefully dried and sold in elegant sachets and potpourris. For the last 1000 years in Europe, rosemary has been a symbol of happiness, fidelity and love, and a wedding and funeral flower (Datiles and Acevedo-Rodríguez, 2014).

Rosemary widely used in various industries. In food industry, rosemary used for flavouring, preservative , and for food additive. Addition of aqueous extract of rosemary positively affected the sensory properties of yoghurt (flavour, body and texture, appearance, and overall grade). On the other hand, 25% treatment of rosemary extract with fed has positive effect on growth in African catfish with no apparent effects on health status. In Ethiopia, fresh rosemary leaves known by the name Asmerino and/or YetibseKetel which is to mean seasoning meat and used for food flavoring at many restaurants and hotels. Besides, dried rosemary leaves added to traditional spiced food materials preparations. Rosemary essential oil has wide application as row material for various industries like pesticide, pharmaceuticals, and cosmetic and also for folk medicine. Rosemary extracts have preservative benefits and pesticide, properties (Banjaw et al., 2024). First learned about the therapeutic benefits of rosemary when I was a depressed grad student who found herself rubbing some rosemary leaves between her fingers on her way to campus every day. Now, I plant rosemary throughout my garden. Not just so I can smell that woodsy scent when I step out to tend my plants, but also for pest protection. That's right! The smell of rosemary repels common garden pests like carrot flies, slugs, and cabbage worms. It even repels mosquitos if you rub the leaves on yourself. You can even plant rosemary near plants that are prone to pests to mask their scent with this stronger-smelling herb. That's why there's the old garden wisdom to plant rosemary at your garden gate. I take this a little further and plant rosemary anywhere I can fit it. Rosemary is, of course, one of our most popular culinary herbs, and it's long been used to stimulate hair growth, increase blood flow, alleviate muscle pain, and improve memory. It's definitely an herb worth having on hand (major understatement), so let's look at how to plant, grow, and harvest your own organic rosemary (Burke, 2024).

Culinary Uses: Rosemary is a staple herb in Mediterranean cuisine and is widely used in Indian kitchens as well. Fresh or dried rosemary can be used in marinades, salad dressings, and roasted dishes. It pairs exceptionally well with ingredients like garlic, lemon, and olive oil. Due to its strong aroma, rosemary is ideal for slow-cooked dishes (Shibily, 2025).

Medicinal Uses: Rosemary has been known for its medicinal properties for a long time. Rosemary essential oil is commonly used in aromatherapy to reduce stress and enhance mental clarity. Additionally, it has anti-inflammatory properties that make it useful for relieving muscle pain and joint discomfort when applied topically in oils or balms (Shibily, 2025).

Skin and Hair Care: Rosemary is a popular ingredient in natural beauty products due to its ability to improve circulation and stimulate hair growth. The herb's antioxidant and anti-inflammatory benefits make it a valuable component in skincare product (Shibily, 2025).

Ornamental Use: Beyond its practical applications, rosemary is an excellent ornamental plant. With its evergreen foliage and fragrant flowers, it adds aesthetic appeal to gardens (Shibily, 2025). Rosemary, both fresh and dried, has numerous cosmetic, decorative, medicinal, and culinary uses, besides its ornamental appeal. The aromatic oil is added to soaps, creams, lotions, perfumes, and toilet waters. The leaves can be used in sachets and potpourris, as well as in herbal baths, facial steams, hair rinses, and dyes. Rosemary is used as an astringent and cleanser in bath and beauty products. Rosemary water is often called Hungary water since one of the Queens of Hungary was said to bathe in rosemary water every day and that she was so beautiful even in old age that she was asked for her hand in marriage at the age of 75. Rosemary is used to flavor poultry, fish, lamb, beef, tomatoes, mushrooms, cheese, eggs, potatoes, vinegars, and herbal butters. Both the flowers and leaves of rosemary can be used in cooking and for garnishes (HORT, 2025). Rosemary leaves are used as a flavoring in foods, such as stews, stuffing, roasted meats, and marinades. Fresh or dried leaves are used in traditional Mediterranean cuisine, having an aroma of pine which complements many cooked foods. Herbal tea can be made from the leaves. In some cooking, the woody stem, stripped of its leaves, is used as a skewer. Hungary water, dating to the 14th century, was one of the first alcohol-based perfumes in Europe, and was primarily made from distilled rosemary. Rosemary oil is used in perfumes, shampoos, cleaning products, and aromatherapy. Rosemary essential oil contains some 150 phytochemicals, including rosmarinic acid, camphor, A-pinene, caffeic acid, ursolic acid, betulinic acid, carnosic acid, and carnosol. Rosemary essential oil contains 10–20% camphor. Rosemary extract, specifically the type mainly consisting of carnosic acid and carnosol, is approved as a food preservative in several countries, having E number E392 (Cancio and Vandalsen, 2025). Rosemary was considered sacred to ancient Egyptians, Romans, and Greeks. In *Don Quixote* (Part One, Chapter XVII), the fictional hero uses rosemary in his recipe for balm of fierabras. It was written about by Pliny the Elder (23–79 CE) and Pedanius Dioscorides (c. 40 CE to c. 90 CE), a Greek botanist (amongst other things). The latter talked about rosemary in his most famous writing, *De Materia Medica*, one of the most influential herbal books in history. The plant has been used as a symbol for remembrance during war commemorations and funerals in Europe and Australia. Mourners would throw it into graves as a symbol of remembrance for the dead. In Australia, sprigs of rosemary are worn on ANZAC Day and sometimes Remembrance Day to signify remembrance; the herb grows wild on the Gallipoli Peninsula, where many Australians died during World War I (Cancio and Vandalsen, 2025). Several Shakespeare plays refer to the use of rosemary in burial or memorial rites. In Shakespeare's *Hamlet*, Ophelia says, "There's rosemary, that's for remembrance. Pray you, love, remember." It likewise appears in Shakespeare's *Winter's Tale* in Act 4 Scene 4, where Perdita talks about "Rosemary and Rue". In Act 4 Scene 5 of *Romeo and Juliet*, Friar Lawrence admonishes the Capulet household to "stick your rosemary on this fair corse, and as the custom is, and in her best array, bear her to church." It is also said that "In the language of flowers it means 'fidelity in love.' Rosemary is one of the four herbs mentioned in the refrain of the folk song "Scarborough Fair." In the Spanish fairy tale The Sprig of Rosemary, the heroine touches the hero with the titular sprig of rosemary in order to restore his magically lost memory. Rosemary is used in Danube Swabian culture for christenings, weddings, burials and festivals; for example, an apple with a sprig of rosemary in it is used for Kirchweih celebrations (Cancio and Vandalsen, 2025).

Nutritional Value: Dried rosemary contains per 100 g edible portion: water 9.3 g, protein 4.9 g, total lipids 15.2 g, carbohydrates 46.5 g, fibre 17.6 g, ash 6.5 g (Ca 1.3 g, Fe 29 mg, Mg 220 mg, P 70 mg, K 955 mg, Na 50 mg, Zn 3.2 mg), ascorbic acid 61.2 mg, thiamine 0.51 mg, niacin 1.0 mg, vitamin A 3128 IU, and phytosterols 58 mg. The energy value is 1387 kJ/100 g (Datiles and Acevedo-Rodríguez, 2014). The main components of rosemary oil are 1,8-cineol (15–20 %), camphor (15–25 %), borneol (16–20 %), bornyl acetate (up to 7 %), α-pinene (25 %); in addition, the oil contains minor amounts of β-pinene, linalool, camphene, subinene, myrcene, α-phellandrene, α-terpinene, limonene, *p*-cymene, terpinolene, thujene, copalene, terpinen-4-ol, α-terpineol, caryophyllene, methyl chavicol and thymol. The initial distillation fraction contains mostly α-thujene, α-pinene, camphene, β-pinene and 1,8-cineol, while camphor and bornyl acetate constitute the bulk of the later distillation. Rosemary oil exhibits variation in composition, both profile and percentage of each component, depending on growing location and/or other factors such as source population, fertilizers and phenology. A study of Moroccan rosemary oil not only demonstrated the existence of three different rosemary chemotypes but also identified a total of 91 compounds, based on GC and GC–MS studies (Berdahl and McKeague, 2015).

Composition of dried rosemary leaves**:**

Moisture	5.7 %
Protein	4.5 %
Fat	17.7 %
Crude fibre	19.0 %
Carbohydrates	47.4 %
Ash	6.0 %
Calcium	1.5 %
Phosphorous	0.7 %
Iron	0.03 %
Sodium	0.004 %
Potassium	1.0 %
Vitamin A	175 IU/100 g
Vitamin B	0.51 mg/100 g
Vitamin C	61.3 mg/100 g
Energy	440 calories/100 g

Rosemary widely used in various industries. In food industry, rosemary used for flavoring, preservative and for food additive. Addition of aqueous extract of rosemary positively affected the sensory properties of yoghurt (flavour, body and texture, appearance, and overall grade). On the other hand, 25% treatment of rosemary extract with fed has positive effect on growth in African catfish with no apparent effects on health status. In Ethiopia, fresh rosemary leaves known by the name Asmerino and/or Yetibse Ketel which is to mean seasoning meat and used for food flavoring at many restaurants and hotels. Besides, dried rosemary leaves added to traditional spiced food materials preparations. Rosemary essential oil has wide application as row material for various industries like pesticide, pharmaceuticals, and cosmetic and also for folk medicine. Rosemary extracts have preservative benefits and pesticide, properties (Banjaw *et al.,* 2024). Many scholars reported the chemical composition of rosemary essential oil. Chemical composition study in Greece showed as the major constituents were α-pinene (24.1%), camphor (14.9%), 1,8-cineole (9.3%), camphene (8.9%), α-terpineol (8.8%) and borneol (8.0%). Whereas study in China revealed as 1,8-Cineole (26.54%), α-Pinene (20.14%), Camphor (12.88%), Camphene (11.38%) and β-Pinene (6.95%) were the major constituents. In Italy, α-pinene and 1,8-cineole identified as the major constituents. In Brazil, α-pinene followed by camphene reported as the major constituents of rosemary. Moreover, reported α-Pinene, 1,8-cineole and camphor as the main compositional constituents of rosemary. In Ethiopia, similar compounds were identified as major components of rosemary essential oil (1, 8-cineole, verbenone, camphor, α-terpineol, isoborneol, tridecyl acrylate, linalool, bornyl acetate, *trans*-caryophyllene, terpine-4-ol, and α-pinene. In their chemical characterization study of rosemary essential oil. It wsa also reported that α -pinene (50.8 %), 1, 8-cineole (24.4 %), camphene (5.2 %), camphor (3.8 %), caryophyllene (2.9 %) and β-pinene (2.1 %) were the major chemical composition of rosemary oil in Ethiopia (Banjaw *et al.,* 2024).

Rosesemary essential oil extract was effective in controlling maize fungal disease. The importance of rosemary essential oil as fumigant against bruchid under the storage conditions was reported. The potential of rosemary fresh leaves and branches to improve potato storage life because of its simplicity and efficacy in decreasing storage cost, the weight loss and sprouting without causing any environmental toxicity was reported. On the other hand, rosemary essential oil components have antimicrobial activity (antibacterial, antiviral and antifungal properties) (Banjaw *et al.,* 2024). Rosemary has many medicinal applications such as treatment of disorders associated with the nervous, cardiovascular, gastrointestinal, genitourinary, menstrual, hepatic, and reproductive systems and with respiratory and skin conditions. Moreover, in addition to its industrial and cultural uses, rosemary has social and environmental benefits. Rosemary nursery and production was being seen as business because of the employment opportunities. Besides, there was scientifically proved environmental benefits of rosemary cultivation. The authors reported that, integration of rosemary plant strips on farmland improves the existing systems, by fomenting complex biological interactions and controlling erosion. Thus, rosemary in hilly areas provides an effective system for trapping agricultural runoff as well as reducing soil erosion, thereby avoiding the soil degradation. It was also indicated that yield penalty due to rosemary incorporation to the farmland can be overcome from rosemary either leaf or essential oil yield (Banjaw *et al.,* 2024).

- **Health Benefits:** osemary is high in Manganese, which helps maintain metabolic health. It also helps the body in the formation of blood clots, which enables injuries to heal faster (Sahua and Sahu, 2024).
- **Potentially Reduced Risk of Cancer**: Rosemary contains carnosic acid, which is a compound known for its powerful antioxidant properties. Research has shown that carnosic acid can slow the growth of cancer cells in the body and even lower the risk of developing tumors.
- **Immune System Support**; Research has indicated that carnosic and rosmarinic acids found in rosemary have potent antibacterial, antiviral, and antifungal properties. Therefore, frequent consumption of rosemary may help reduce the likelihood of infection and support the immune system in fighting infections if they occur.
- **Stress Relievement**: More studies may be necessary, but available data from initial studies suggest that rosemary has a beneficial impact on decreasing anxiety and stress levels. Rosemary was established in one randomized trial to help university students sleep better with less anxiety than a control placebo group.
- **Improved Memory and Concentration**: There is a long history of using rosemary to improve memory, but studies in aromatherapy using rosemary have borne out some of these legends. So, for example, one study noted significant improvements in cognitive performance after just 20 minutes inhaling rosemary essential oil (Sahua and Sahu, 2024).

The medicinal properties of rosemary are largely attributed to its rich chemical composition. Key compounds include:

- **Rosmarinic Acid**: A potent antioxidant and anti-in Áammatoryagent.
- **Carnosic Acid and Carnosol**: Known for their neuroprotective and anti-cancer properties.
- **Essential Oils (1,8-Cineole, Camphor, and α-Pinene):** Possess antimicrobial, anti-in Áammatory, and respiratory benefits. This section will detail the molecular structures of these compounds and their specific health benefits. (Rana and Singh, 2024).

Antioxidant and Anti-in Áammatory Effects: One of the primary medicinal properties of rosemary is its strong antioxidant activity, which helps neutralize free radicals that can cause cellulardamage.Theanti-inÁammatoryeffectsare particularly beneficial for conditions like arthritis and cardiovascular diseases. This section will explore the mechanisms by which rosemary exerts these effects, backed by studies that demonstrate its efficacy in reducing oxidative stress and in Áammationin both invitro and invivo models (Rana and Singh, 2024).

Cognitive Enhancement and Neuroprotective Effects: Rosemary has long been associated with memory enhancement and mental clarity. Recent studies have provided evidence supporting its use as a cognitive enhancer, particularly in the prevention and management of neurodegenerative diseases like Alzheimer's. The chapter will discuss how rosemary's active compounds, particularly rosmarinic acid and carnosic acid, protect neuronal cells from damage, promote brain health, and improve memory and concentration. Antimicrobial and Antiviral Properties Rosemary's essential oils exhibit strong antimicrobial properties, making the herb effective against a range of bacteria, fungi, and viruses. This section will detail the specific pathogens that rosemary can combat, including its use as a natural preservative in food and cosmetic industries.

- Harvest sprigs by cutting stems just above a leaf node to encourage regrowth.
- Avoid over-harvesting, as this can weaken the plant.

Its antioxidant properties also support metabolic health, potentially aiding in weight management by enhancing fat metabolism and reducing oxidative stress associated with obesity (Rana and Singh, 2024).

Skin and Hair Care: Rosemary's benefits extend beyond internal health; it plays a significant role in skin and hair care. The chapter will explore how rosemary oil and extracts can be effectively used to treat acne due to their antimicrobial properties, which help combat the bacteria that contribute to breakouts. Moreover, rosemary has been shown to improve skin elasticity, making it a popular ingredient in anti-aging formulations. In terms of hair care, rosemary oil is renowned for promoting hair growth by stimulating blood circulation to the scalp, which nourishes hair follicles and encourages stronger, healthier hair. The mechanisms behind these effects, including rosemary's ability to enhance circulation and provide antioxidant protection, will be examined in detail (Rana and Singh, 2024). In contemporary medicine, rosemary is increasingly integrated into various health practices, particularly in the form of supplements, essential oils, and herbal teas. This section will discuss current trends in rosemary usage, including its incorporation into clinical practices and alternative therapies. For instance, rosemary essential oil is used in aromatherapy for stress relief and cognitive enhancement. Additionally, the potential of rosemary in future medical applications will be explored, particularly regarding the development of new therapeutics targeting conditions such as neurodegenerative diseases, metabolic disorders, and even certain types of cancer. By bridging traditional uses with modern scientific research, rosemary holds promise as a multifaceted herb with significant therapeutic potential (Rana and Singh, 2024).

Supplementation and Herbal Teas

- Rosemary supplements, available in capsule or tablet form, are widely used for their antioxidant and anti-in Áammatory properties.
- Rosemary herbal teas are popular for their digestive benefits and are often recommended for soothing indigestion, bloating and gas.
- These supplements and teas are increasingly prescribed as complementary therapies for conditions like arthritis, high blood pressure, and anxiety. (Rana and Singh, 2024).

Essential Oils in Aromatherapy

- Rosemary essential oil is a staple in aromatherapy, used to enhance memory, concentration, and mental clarity.
- It is often diffused in clinics and wellness centers to reduce stress and anxiety in patients, particularly before surgeries or medical procedures.

- The oil is also applied topically in diluted form to relieve muscle pain, improve circulation, and promote hair growth. (Rana and Singh, 2024).

Topical Applications for Skin and Hair Health:

- Rosemary extracts are incorporated into dermatological products for their antimicrobial and anti-in Áammatory properties, aiding in the treatment of acne, eczema, and other skin conditions.
- In hair care, rosemary oil is used in shampoos and scalp treatments to combat dandruff, stimulate hair follicles, and prevent premature graying. (Rana and Singh, 2024).

Rosemary Soap

Use in Neurological Health:

- Emerging research supports rosemary's role in neuroprotection, particularly in the prevention and management of Alzheimer's disease and other forms of dementia.
- Clinical trials have shown that rosemary extracts can improve cognitive function in aging populations, with potential applications in memory supplements and neuroprotective therapies.
- Some neurologists recommend rosemary-based products as part of a holistic approach to managing cognitive decline. (Rana and Singh, 2024).

Incorporation into Anti-in Áammatory Treatments:

- Rosemary'santi-inÁammatoryproperties are harnessed in the development of natural treatments for chronic inÁammatory conditions, such as rheumatoid arthritis and inÁammatory bowel disease.
- It is also being studied as a natural alternative or complement to nonsteroidal anti-inÁammatory drugs (NSAIDs), offering fewer side effects (Rana and Singh, 2024).

Antimicrobial Uses in Clinical Settings:

- Rosemary's potent antimicrobial properties are utilized in hospitals and clinics as a natural disinfectant and preservative.
- It is incorporated into wound care products to prevent infections and promote faster healing.
- Rosemary oil is also being researched for its potential to combat antibiotic-resistant bacteria, offering a natural solution to a growing medical challenge. (Rana and Singh, 2024).

Cardiovascular Health Applications

- In cardiology, rosemary is explored for its potential to improve heart health by reducing oxidative stress, lowering cholesterol levels, and managing hypertension.
- Rosemary extracts are included in some natural supplements designed to support cardiovascular function and prevent heart disease (Rana and Singh, 2024).

Integrative Oncology:

- Oncology clinics are beginning to explore rosemary's potential as a complementary therapy in cancer treatment, particularly for its anti-cancer and immune-boosting properties.
- Rosemary is being researched for its ability to reduce the side effects of chemotherapy and radiation, such as nausea and fatigue, and for its potential role in preventing cancer recurrence (Rana and Singh, 2024).

Gastroenterology

- Rosemary is recommended by gastroenterologists for its role in improving liver function and detoxifcation processes, often used in liver cleansing protocols.
- It is also explored as a treatment for gastrointestinal disorders like IBS (Irritable Bowel Syndrome) due to its spasmolytic and carminative effects. (Rana and Singh, 2024).

Development of New Pharmaceuticals

- Pharmaceutical companies are investigating the active compounds in rosemary, such as rosmarinic acid and carnosic acid, for the development of new drugs.
- These compounds are studied for their potential to treat various diseases, including neurodegenerative disorders, cancers, and chronic in Áammatory conditions.
- Research is ongoing to create standardized rosemary-based medications with specific dosages for clinical use. (Rana and Singh, 2024).

CULTIVATION

Cultivation: Rosemary is drought tolerant, easy to grow and relatively pest resistant. It grows well in sandy to clay loam soil with good drainage and in full sun, and best under neutral to alkaline conditions. Transplanting to the field is done at a spacing of 45 cm between plants in rows 1.2 m apart. It is also common to produce rosemary in containers in greenhouses. Rosemary is very tolerant to pruning; plants can regenerate from old wood. Rosemary benefits from balanced fertilizer applications, with K being particularly critical for high essential-oil yield. In cold areas, the crop should be given heavy mulching to prevent winter injury. It should only be moderately watered to prevent root rot. Growth of rosemary raised in containers strongly depends on the type of growing medium and the fertilizer regime used. The use of peat and perlite as growing medium results in taller plants yielding higher amounts of essential oil compared with those raised in a medium of peat, perlite and soil. Plant fresh weight, however, is not affected. Growth in both media is also satisfactory when plants are provided with an adequate supply of controlled-release or liquid fertilizers (Datiles and Acevedo-Rodríguez, 2014).

Growing Conditions

- **Soil and climate:** Rosemary needs a well-drained loamy soil with a pH of 5.5 to 7.0. If the pH is below 5.0, dolomite @ 2.5t/ha should be applied and mixed well in the soil. It needs cool winter and mild summer below 30° C. The temperate climatic zones ranging from 900 to 2500 m above MSL are suitable for rosemary cultivation.
- **Season:** The stem cuttings of rosemary plants can be planted during the months of June-July and September - October through rainfed conditions.
- **Duration:** It is a perennial crop and commercially viable up to 12 years.
- **Preparation of field:** Dig the land thoroughly two times and bring it to fine tilth. When last ploughing time has come, apply the mixture of 25 tons well decomposed FYM and 500 kg of neem cake mixed well. Beds preparing for 30 cm heights with 1.5 m in width and of convenience in size. When the transplanting time has come the addition of 5 kg Azospirillum and 5 kg of Phosphobacterium have to be done upon soil mix well.
- **Planting material:** 50, 000 plants/ha.
- **Propagation:** Select 10 - 15 cm length semi hardwood cuttings before flowering leaving upper few whorls intact at the top, the remaining leaves should be removed from the cuttings before planting. The cuttings should be planted in a mixture of soil, sand and leaf molds in polythene bags for rooting. 3% solution of Panchagavya or 10% CPP solution can be used to soak the cuttings for 20 minutes before planting. This treatment increases the rooting percentage of the cuttings. The bags should be kept under shade and regularly watered twice daily. The rooted

cuttings will be ready in 60 days for transplanting in the main field.

- **Planting:** The planted spacing should be about 45 x 45 cm for the cuttings from rosemary. Removing the middle shoot should occur 6 months after planting when to allow the shoots for the rosemary.
- **Irrigation:** Crop can be grown in rainfed conditions as a dry farming crop. Irrigation during drought will enhance herbage production.

Fertilizer requirement:

- Well decomposed farm yard manure @ 50 t/ha and Biodynamic compost @ 5 t/ha
- Application of vermicompost @ 5 t/ha
- Neem cake @ 1.25 t/ha
- Azospirillum and Phosphobacterium @ 25 kg/ha
- Foliar spraying of Panchagavya, an organic preparation @ 3 per cent at monthly intervals should be done. Panchagavya sprayed 5 times a year will increase the yield and quality of the green leaves.
- After cultivation: First hoeing and weeding should be done one month after planting. Four to five weeding should be done in a year. Foliar spraying of 5% neem oil, 10% vermiwash and 3% dasagavya should be done once in a month.
- Plant protection: It is free from pests and diseases.
- Yield: Green leaf yield: 12-13 t/ha.
- Harvesting: Rosemary leaves are harvested with the onset of flowering. The flowering tops measuring 30-35 cm long with leaves are harvested with a sickle. All the shoots can be used for distillation at the stage when they attain maximum size but before becoming woody. This is because hard wood shoot on distillation gives an undesirable odour of turpentine. The crop becomes ready for harvesting at 215 days after plantation in the first year. Subsequently, three harvests per annum at equal interval can be taken. Three harvests can be done annually at an interval of 3-4 months.
- Harvesting of leaves: It has been washed thrice for removal of various dirt and soil particles. Under shade it should be dried. The leaves can be taken to the plains and dried under a shade with electric fan on clean cement floor. In about 3 days up to 10% moisture level may be reached and then it can be packed in food grade poly bags.
- Yield: 2.5 t/ha of dried leaves/year.
- Distillation of rosemary oil: Steam distillation of freshly gathered twigs or leaves yields essential oil. It is possible to shade dry them, store, and then distill at any time as there is no loss of the oil. The distillation should always be continuous for 120 minutes to achieve maximum yield of rosemary oil.
- Oil yield: 80-100 kg/ha. ((Kassahun et al., 2016; Sahua and Sahu, 2024).

Climate requirements: Rosemary thrives in warm, Mediterranean-like climates, characterized by dry summers and mild winters. It prefers temperatures between 15 °C and 25 °C but can tolerate temperatures as low as -6 °C if established.

- Cold Tolerance: Although rosemary is hardy, it can suffer damage in regions with severe frost. In colder areas, it's advisable to grow rosemary in containers or provide winter protection, such as mulching or using frost covers.
- Heat Tolerance: Rosemary is well-adapted to withstand drought conditions, making it suitable for dry and hot regions, but prolonged exposure to intense heat without adequate water can stress the plant.(Rana and Singh, 2024).

Light requirement: Rosemary prefers full sunlight and requires at least 6-8 hours of direct sunlight daily. In low-light conditions, the plant may become leggy and produce fewer aromatic oils, which are crucial for its medicinal and culinary value (Rana and Singh, 2024).

Soil requirement: Rosemary thrives in well-drained, sandy, or loamy soils with a slightly acidic to neutral pH range of 6.0 to 7.5. Poorly drained or waterlogged soils can lead to root rot, which is one of the most common causes of failure in rosemary cultivation (Rana and Singh, 2024).

Soil Preparation: Before planting, it is essential to ensure good drainage by amending the soil with organic matter like compost or well-rotted manure. Adding sand or gravel can also improve soil aeration (Rana and Singh, 2024).

Container Growing: Rosemary grows well in pots or containers, particularly in regions with cold winters. Choose containers with adequate drainage holes, and use a well-draining potting mix. Clay or terracotta pots are preferred for their breathability, which helps prevent water retention (Rana and Singh, 2024). Rosemary cultivation and handling have essential steps. These comprise seedling preparation, land preparation, transplanting, field management, harvesting, processing, packaging, transportation, and storage (Banjaw et al., 2024).

Planting Time: For outdoor planting, rosemary should be transplanted after the danger of frost has passed. In regions with a temperate climate, early spring is ideal for planting (Rana and Singh, 2024).

Spacing: Rosemary plants need ample space forair Áowand growth. Forlargervarieties, space plants 60 to 90 cm (24 to 36 inches) apart. Smaller varieties or container-grown rosemary can be spaced 30 to 45 cm (12 to 18 inches) apart (Rana and Singh, 2024).

Companion Planting: Rosemary grows well with other Mediterranean herbs such as sage, thyme, and oregano. It can also be planted alongside vegetables like carrots and beans, where it acts as a natural pest repellent due to its strong aromatic oils (Rana and Singh, 2024).

Irrigation: Rosemary is drought-tolerant once established and does not require frequent watering. Overwatering can lead to root rot, so it is important to allow the soil to dry out between watering (Rana and Singh, 2024).

Young Plants: Water young plants regularly until they are well-established (Rana and Singh, 2024).

Mature Plants: Water only when the top inch of soil feels dry, especially during hot weather or prolonged dry periods (Rana and Singh, 2024).

Drip irrigation is an efficient and water-saving method for irrigating rosemary, particularly suited to its drought-tolerant nature. This system delivers water directly to the plant's root zone through a network of tubes and emitters, minimizing water wastage and reducing evaporation. Since rosemary prefers well-drained soil and can be prone to root rot in waterlogged conditions, drip irrigation ensures that the plant receives consistent moisture without overwatering. The slow, controlled delivery of water allows the soil to absorb moisture gradually, promoting deeper root growth and healthier plants. Drip irrigation also helps prevent the wetting of foliage, which can reduce the risk of fungal diseases. Overall, using a drip irrigation system in rosemary cultivation provides precise water management, improves plant health, and supports sustainable growing practices (Rana and Singh, 2024).

Fertilization: Rosemary is not a heavy feeder, but it benefits from occasional fertilization, particularly when grown in poor soils or containers. An application of a balanced, slow-release fertilizer once or twice during the growing season is sufficient (Rana and Singh, 2024).

Organic Options*:* The best time to prune rosemary is during spring or early summer when the plant is actively growing. Begin by removing any dead, damaged, or diseased branches to improveair Áowand

reduce the risk of pests and diseases. For shaping, trim back about one-third of the plant's height, focusing on cutting just above a leaf node to encourage new growth. Avoid cutting into the older, woody stems, as rosemary regenerates slowly from these areas and may struggle to recover. Regular, light pruning throughout the growing season also helps maintain the plant's shape and ensures better foliage density, which is important for optimal harvests (Rana and Singh, 2024).

***Mulching**:* Mulching in rosemary cultivation is a beneficial practic t hat helps conservesoilmoisture, regulate temperature, and suppress weed growth. To mulch rosemary, apply a 2-3 inch (5-7 cm) layer of organic mulch, such as straw, bark chips, or compost, around the base of the plant, leaving a small gap around the stem to prevent moisture buildup and potential rot. Mulching is particularly important for rosemary plants in hot climates, as it helps retain soil moisture while preventing the soil from becoming too hot. In colder regions, mulching can also offer some protection to the roots from frost during winter. Regularly check the mulch layer to ensure it remains effective, replenishing it as necessary to keep the soil healthy and weed-free. The slow, controlled delivery of water allows the soil to absorb moisture gradually, promoting deeper root growth and healthier plants. Drip irrigation also helps prevent the wetting of foliage, which can reduce the risk of fungal diseases. Overall, using a drip irrigation system in rosemary cultivation provides precise water management, improves plant health, and supports sustainable growing practices (Rana and Singh, 2024).

Harvesting Rosemary can be harvested year-round, with the best time being just before Áowering, when the Concentration of essential oils is highest (Rana and Singh, 2024).

Site selection: Rosemary can grow in pots or herb gardens (Fig. 3). Most varieties grow best in well-drained, loamy, slightly acidic soil. The preferred soil pH is between 6.0 and 7.0. Rosemary should receive at least 6 hours of sun each day; it grows best in full sun. If you plan to use rosemary as a perennial plant, choose a site that will not be disturbed by tilling (Masabni and Gu, 2025).

Soil preparatio**n** (Masabni and Gu, 2025).

Follow these steps to prepare the soil:

1. Remove all rocks, shrubs, weeds plant debris, and tree roots from the area to be planted.
2. Collect a soil sample and have it analyzed to determine your soil's fertility level. For Like most herbs, rosemary is fairly drought resistant and, if healthy enough, can tolerate a light freeze. It is most successful when grown from cuttings or transplants. Although seed is readily available and usually inexpensive, its germination rate is usually only about 15 percent.

The best way to propagate rosemary is by taking a cutting from an already vigorous plant (Masabni and Gu, 2025):

- Clip a 3-inch branch from the stem of the plant.
- Trim off most of the lower leaves to 1½ inches up the stem.
- Plant one or two cuttings into a 3-inch pot.
- Water the cuttings.
- Place the pot in a windowsill with indirect sunlight and temperatures between 60°F and 70°F.
- After about 8 weeks, the cuttings will be rooted and ready for transplanting to their permanent location.

***Fertilizing*:** Rosemary seldom needs fertilizer. But if growth is slow or the plant appears stunted or pale yellow, apply fertilizer once in early spring before new growth appears. Any all-purpose fertilizer in dry or liquid form is suitable as long as you apply it correctly. To prevent leaf burning, do not apply it directly to the plant. In herb gardens, it is often planted with thyme, oregano, sage, and lavender. When planting, choose a variety that is suitable for the climate, soil, and desired use (Masabni and Gu, 2025).

Watering: oo much water can cause root rot. Because its needles do not wilt as broad leaves do, sometimes it can be difficult to determine when a rosemary plant needs water. On average, water rosemary every 1 to 2 weeks, depending on the plant size and climate conditions. Allow the plants to dry out thoroughly between each watering (Masabni and Gu, 2025).

Significance of Rosemary Leaves: The leaves of rosemary are rich in bioactive compounds, mainly essential oils, flavonoids, and phenolic acids. These compounds contribute to rosemary's wide array of health benefits, ranging from antimicrobial properties to cognitive enhancement. Understanding the components and potential of rosemary leaves is crucial for maximizing its use in health, agriculture, and industry (Sahua and Sahu, 2024).

Morphological Features of Rosemary Leaves: The leaves of rosemary are rich in bioactive compounds, mainly essential oils, flavonoids, and phenolic acids. These compounds contribute to rosemary's wide array of health benefits, ranging from antimicrobial properties to cognitive enhancement. Understanding the components and potential of rosemary leaves is crucial for maximizing its use in health, agriculture, and industry. Rosemary flowers are pale violet, white or light blue and pinkish in color. The flowers grow in two or more at the upper ends of the plant. Their shape is like that of the upper and lower lip of a mouth. This is typical of the other plants of the mint family, also called Labiatae, meaning "having lips". The flowers have long protruding stamens (Sahua and Sahu, 2024).

Economic /Beneficial/ Plant Parts: The economic parts of rosemary plant are leaves (fresh and dry), flower twigs, and the essential oil obtained from herbal products. Hence, cultivation and wild harvesting of rosemary is manly for its needle-like leaves that can be utilized in the form of either solid or liquid through different value addition practices (Banjaw *et al.,* 2024).

Rosemary Marketing: Global demand for fresh and dry leaves of rosemary has increasing trend in both price and quantity. Besides, global demands for rosemary essential oil have increasing trend. Population growth, growing knowledge of the advantages of rosemary products,rising popularity of organic foods and substances, increase in health problems, increased consumers interest for organic natural products, and growth in industries thought to be the major reasons behind the increment of rosemary products. Due to the high demand for it as a food additive and a food/drink ingredient, the rosemary extracts market was estimated at USD 215 million in 2019 and is anticipated to grow at an annual rate of 3.7 percent between 2020 and 2025 (Banjaw *et al.,* 2024).

Planting: 45 cm row to row and plant cetikkuc vittac root plants should be transplanted in 45 cm intervals. And 6 months after planting, the plant should be cut maiyattantai. By doing so, the plant grows well in the lateral branches (Mahr, 2025).

Water cannon: Drought tolerance is also suitable for planting in dry land. Green leaf with water in dry periods payccutalin get higher yield (Mahr, 2025).

Manures/Practices: Basal FYM 50 t / ha, neem cake @ 1 t / ha, the natural life force Compost 5 t / ha and vermin-compost compost 5 t / ha can be applied as a seedling natumpolutu. Phosphobacterium bio-fertilizers, bio-fertilizers and inoculant and 5 kg per ha as basal dose required (Mahr, 2025).

Application of bio-fertilizers: Supplying fertilizers, such as from the second year after planting survival rate of 5 kg to 30 kg per hectare should be applied with FYM. The solution of 3 per cent per year, 5 times more pancakavyam telippatin the leaves will increase the quality and yield (Mahr, 2025).

Climatic and soil requirements: The climatic conditions prevailing in Nilgiris and the sandy loam soils of Bangalore are found to be suitable. It grows well in areas where the rainfall is higher than 500

mm per annum. The crop comes well in a pH range of 6.5 to 7.0 (Mahr, 2025).

Propagation: osemary is propagated by means of seeds, cuttings, layers and division of roots. Commercial propagation is through 10-15 cm cuttings which are planted in the nursery beds and after about 6-8 weeks they can be transplanted in the main field (Mahr, 2025).

Planting: The rooted cuttings or seedlings are planted in the field at 45X45 cm spacing (Mahr, 2025).

Manures: Application of FYM at 20 t/ha and 20:40:40 kg NPK per ha has to be given prior to application. Then after each harvest, 80 kg n/ha has to be given in 4 equal split doses (Mahr, 2025).

Irrigation: When establishing rosemary, it has to be irrigated twice a week. After establishment, it can be irrigated once in a week (Mahr, 2025).

Weed control: The crop requires 5-6 earthing up and weeding during the crop growth. When the crop attains 2-3 years, the bushes are pruned to accelerate the formation of more vegetative shoots to increase the oil yield (Mahr, 2025).

Pest and disease control: Rosemary is vulnerable to spider mites, mealy bugs, Whiteflies and thrips. Late blight disease has been reported which can be controlled by drenching the plant with Maneb (1%) at 8-10 days interval (Mahr, 2025).

Harvest: The first harvest of leaves begins from 8 months after planting, and subsequent harvests can be done at an interval of 3 to 4 months. Annually three to four harvests can be had, and this perennial crop can be retained for upto twelve years, based on the vigour of the crops. Harvest will commence at the time of 50% blooming and continues till 75-90 % inflorescence emergence and must end when the flowers have finished blooming (Mahr, 2025).

Yield: On an average, about 12-15t/ha/annum of herbage and an oil yield of about 85 to 100 kg/ha/annum can be obtained (Mahr, 2025).

Processing leaves: The leaves are harvested in the soil and removing the dust should wash three times. Then dried in the shade. Nilgiris dried up in the 10 to 15 days. Exactly equal to the plain areas, such as dried leaves, leaves scene to take concrete floor ventilation caused by the electric fan to keep dry. In the three days, with 10 percent moisture can get good quality leaves. Then the quality of the food to be stored in a Polyethylene bags (Mahr, 2025).

Yield: 2.5 tonnes per ha per year of dried leaves (Mahr, 2025).

Rosemary oil: After harvesting the stem and leaves of rosemary oil obtained by steam distillation. Number of leaves can be dried in the shade of the same size. Subjecting to 120 minutes of continuous steam distillation and the number of doses can be high (Mahr, 2025).

Oil yield: 80 to 100 kg per ha; Cost: Rs 65,000 / - ; Income per acre Rs 1,25,000 / - lakh (Mahr, 2025) (Mahr, 2025).

Harvesting: Once the plant grows to a suitable size, you can pick several small branches without harming it. Nursery plants can be harvested sooner than can cuttings or seeds (Table 1). Although you may harvest rosemary several times in a season, allow the plants to replace their growth between harvests. The clippings can be used fresh or dried for later use (Fig. 4). Fresh cuttings retain their best flavor for 2 to 7 days in the refrigerator. To store rosemary longer, hang it in bundles to dry (Masabni and Gu, 2025).

Cultivation and Harvesting Practices: Rosemary can be grown in a wide range of environmental conditions. It can tolerate drought and frost conditions. Rosemary grows well in areas that has an average temperature ranges from 20 to 25oc, and receive above 500 mm average annual rainfall. However, if the soil is dry at the time of seedling transplanting; it needs to be irrigated. Rosemary thrives within an altitude range from 1500 up to 3000 meters above sea level. Rosemary requires well drained sandy to clay loam soil with a pH range of 5.5 to 8.0. It does not grow well in waterlogged or high clay soils. If the clay content of the soil is high, incorporation of compost or fine gravel can amend the soil for rosemary production (Sahua and Sahu, 2024).

Harvesting of Rosemary*:* Rosemary grows the most vigorous during spring and summer, but it can be gathered at practically any time of the year. And just before the plant flowers, its leaves are the most savory and aromatic. Remove 4- to 6-inch stem tips using pruners to harvest. You may cook with fresh rosemary leaves or sprigs as you prefer. Or else you may hang the stems upside-down in a dry, cold, well-ventilated room for a few weeks to dry them out. When the stems have dried remove the leaves and store in a pantry in an airtight container (Sahua and Sahu, 2024). Once established, but before rosemary becomes woody, the terminal shoots (25-30 cm from the tip) are harvested once or twice each season. The shoots are either dried or, if for sale in the fresh-herb market, bundled together in bunches of 8-12, tied with rubber bands. When the essential oil is to be extracted the plants are cut 2-3 years after planting at the onset of flowering, when the oil content is at its maximum. Bunched fresh shoots of rosemary are put in styrofoam containers and delivered as soon as possible to fresh-market outlets. The whole fresh leaves can be frozen, preserving the flavour best. For the dried herb market, the shoots should be dried immediately on screen trays in a dark, sheltered area with good ventilation. The dried leaves are simply stripped by hand from the stems and subsequently stored in closed containers (Datiles and Acevedo-Rodríguez, 2014). Yields of fresh leaves of rosemary amount to 3 t/ha, and with a content of 0.1%, essential-oil yield is approximately 3 kg/ha (Datiles and Acevedo-Rodríguez, 2014). Proper harvesting stage, harvesting time, harvesting season, drying method and packaging material play great role in quality and quantity of rosemary herbal, essential oil and composition. Purpose of the production and harvesting, as well as type of the rosemary variety determine the harvesting stage and harvesting time. It was reported that harvesting rosemary for leaf yield and for essential oil yield at 9 months and at 10 months after transplanting were advantageous. However, rosemary harvesting for fresh leaf marketing could consider the interest of the buyer. The best harvest season to get the most essential oil yield of rosemary is summer and autumn, which reached its.

Applications of Rosemary Leaves in Various Industries : Rosemary flowers and leaves contain an essential oil which has a strong aromatic fragrance, making it a popular ingredient in perfumery, cosmetics, hair products, and incense burners. Rosemary has strong antioxidant properties and contains iron, calcium, and phytonutrients so it is added to hair care products to provide hydration and protection from sun damage. Rosemary's pretty, purple flowers often feature in ornamental garden displays. It thrives in containers and along sunny borders in dry regions. Rosemary is one of the most important herbs used in cooking, most especially in Mediterranean food. They use it to flavour any kind of sweet or salty dish, but it's mostly used with meat dressings. The taste of the leaves is bitter; they balance out the heavy foods like lamb and oily fish. Narbonne honey from France comes mostly from bees that feed on the blossoms of rosemary. The leaves and flowers of rosemary can be prepared to make a tea thought to relieve headaches, colic, colds, and depression. Rosemary has also been reported to have antibacterial and antifungal properties. It was used in traditional European herbal remedies for wounds, eczema, poor appetite, and asthma (Sahua and Sahu 2024).

Rosemary essential oil: Essential oils are located in glandular trichomes, at the bottom of the leaves and within flowering tops. The oil content in leaves varies between 1.0–2.5%, depending on whether the leaves are young, or fully mature and dry. The composition of the essential oil may vary depending on the country of origin, weather and cultivation conditions, as well as the time of harvest, manner of drying and storing. Genetic diversity also plays a part. On the basis of a quantitative evaluation of the composition of oils of different regions including Iran, Morocco, Spain, France, Algeria, Cuba, Argentina, and

Italy, the chemical constituents in common are: α-pinene, β-pinene, 1,8-cineole, camphene, borneol, camphor, linalool, and β-caryophyllene. Major constituents included: β-myrcene, bornyl acetate, verbenone, limonene, and sabinene, which constitute terpene compounds. These 4 main chemotypes, which are characteristic of the different geographical regions, are named according to the predominant constituent: α-pinene chemotype (Iran, Spain, France, Italy, Romania), 1,8-cineole chemotype (Algeria, Austria, Morocco), camphor chemotype (Cuba, India), and myrcene chemotype (Argentina, Portugal). Although these are the most common chemotypes, many other combinations of relative quantitative values of the respective constituents occur. A study made in the Sudan demonstrated that the predominant constituent of the local rosemary oil was bornyl acetate, typically present in only trace amounts of the material from other countries (Sahua and Sahu, 2024).

Methods of Chemical Extraction and Analysis: Essential oil was extracted from each of the plant parts by two extraction methods: Hydro distillation: A mixture of Rosemary leaves or powder (200 g) and 1000 ml of water was taken in a 2000 ml round bottomed flask. The temperature was set at 80C for the extraction of essential oil. The process in Clevenger-type apparatus was run for the time till no further oil could be extracted. The essential oil was vaporized with the steam. Condensation took place as the vapours of the mixture of essential oil and steam passed through a condenser. The condensate, which was a mixture of oil and water, was separated. Essential oil being lighter settled above water and it was collected. In order to study the kinetics of extraction of oil, essential oil was collected at regular intervals during the extraction process (Sahua and Sahu, 2024).

Steam distillation*:* The apparatus had a cylindrical Pyrex body of inside diameter 6 cm and height 60 cm. A batch of 100-200 g of dried and ground leaves of rosemary was packed in the column with 2000 ml water in steam source. The raw material forms the packed bed. The lid was closed and the process of distillation began with the injection of steam to the bottom of the column. Every plant bed was subjected to several flow rates of steam. Steam and essential oil were condensed and collected in time intervals of 5, 15, 30, 60 and 100 minutes. After condensation, the mixture was decanted and separated into oil and water phases. The essential oil was isolated, dried using anhydrous sodium sulfate and stored at 4oC until analyzed. In these experiments, the steam jacket of the column was insulated by foam cover with a thickness of 1 cm. After performing the experiments and calculating the yield of each experiment, the products that resulted from the three experiments using steam flow rates of 3, 6 and 9 l/min and a packed bed of 100 g collected at five intervals, namely 5, 15, 30, 60 and 100 minutes, were analyzed by GC-MS and GC apparatus. Each experiment was carried out at least three times and the mean of the results was presented (Sahua and Sahu, 2024).

Gas chromatography-mass spectrometry identification GC analyses were performed using a Hewlett-Packard 6890 with HP-5 capillary column (phenyl methyl siloxane, 25 m×0.25 mm, 0.25 μm film thickness) and a DB-1 capillary column (30 m ×0.25 mm, 0.25 μm film thickness). Oven temperature was programmed at 4°C/min from 60 to 240°C; injector temperature, 250°C; detector temperature, 260 °C; carrier gas, He (1.5 ml/min); split ratio, 1:25. GC–MS analyses were carried out applying a Hewlett-Packard 6859 with a quadropol detector, on a HP-5 column (see GC), operating at 70 eV ionization energy, using the same temperature programmer and carrier gas (Sahua and Sahu, 2024).

Production and Trade: Data on world trade of dried rosemary are fragmentary and available only for selected markets. In the 1970s annual consumption of rosemary in the major markets of Europe, the USA and Japan was estimated at 490-710 t. In 1989-1990 import of rosemary in selected countries of Western Europe (France, Germany, UK, the Netherlands) totalled 970-1020 t. The bulk of this import came from Spain and the rest from Albania, Tunisia and Morocco. Rosemary oil, which is used in large amounts in the food-processing industry, is produced mainly in Spain, Tunisia and Morocco. Annual world production of the oil is about 375-425 t and is consumed mostly in the USA and the European Union. The value of world production of rosemary oil is estimated at US$ 5 million. From 1992-1995 the biggest user of rosemary oil, the USA, imported annually about 60 t, valued at US$ 0.9 million (Datiles and Acevedo-Rodríguez, 2014). The supply of rosemary is adequate and it is one of the least expensive herbs in the spice trade. Thus, new producers may find it difficult to penetrate the current market. Consumers have increasingly favoured food products which contain natural ingredients due to concerns over the adverse health effects of synthetic raw materials, particularly some synthetic antioxidants and food additives. Rosemary and rosemary products are classified as all natural, 'clean label' and non-GMO, attractive qualities sought by consumers. As consumers' demand for natural ingredients in their food products increases, the utilization of rosemary and rosemary products will continue to expand, and scientific research works on rosemary will continue to increase. Rosemary will remain an important aromatic herb throughout the world for years to come (Datiles and Acevedo-Rodríguez, 2014).

Postharvest Treatment

Fresh clean rosemary leaves devoid of dirt and twigs and extraneous materials should have a fresh and crisp appearance, a dark green colour and a good flavour. Typically, young, fresh shoots are used for culinary purposes. These are typically marketed and sold in bunches of two or three measuring 25-30 cm or in clear cellophane sachets. They are packaged in crates when marketed in bulk. Packaged, fresh rosemary leaves stored at cool refrigerated temperatures (~5°C) can remain fresh for at least 2-3 weeks. Whole fresh leaves can also be frozen, preserving the flavour best. For the dried herb market, the shoots are processed by removing the leaves from the stems and removing any dirt and sand thoroughly by sieving. The leaves are then dried either by spreading out on a tray or hanging in bunches away from direct sunlight. Better results are typically obtained when artificial drying is used rather than sun drying, because the drying and heating can be better controlled. Drying should be done at temperatures lower than 40°C to reduce loss of flavour and to maintain the dark green colour of the leaves. After drying, the leaves are cleaned further (to remove any stems, foreign material, etc.), sieved and graded. The dried product is packaged and stored in tightly sealed containers. Dried rosemary is packaged and sold in either cartons or in glass or plastic containers, tightly sealed and stored at low temperatures to keep moisture, heat, oxygen and light out because these will destroy the quality of the dried herb. Dried whole rosemary leaves of good quality should contain at least 1.2% volatile oil and a maximum of 2% woody stems and a maximum of 7% ash (Datiles and Acevedo-Rodríguez, 2014). In a commercial setting, sterilization of the herb is necessary to destroy pathogenic microorganisms, yeasts and moulds and other pests. There are a number of choices that can be employed: irradiation, microwave sterilization and steam sterilization. The use of ethylene oxide was once popular but has now been banned in Europe and other countries. Irradiation, although not popular to consumers, can effectively kill bacteria, mould and insects while maintaining the flavour of the herb. This is achieved by using γ-rays emitted from cobalt-60 or by an accelerated electron beam. A dosage of 4 to 12-15 kGy can eliminate coliforms or reduce the total plate count to below detectable levels, respectively. Microwave sterilization is a milder method that is also effective and at the same time can preserve the colour and flavour of the herb (Datiles and Acevedo-Rodríguez, 2014).

In addition to drying and sterilization, rosemary is processed using a variety of extraction methods to produce rosemary oil, a very important product in the aromatic herb market. The parts used for extraction are the stems, leaves and flowers, but rosemary oil extracted from the flowering tops gathered when the plant is in bloom produces superior oil compared with that obtained from the stems and leaves. The oil produced from this process is a clear to slightly yellow, thin oil with a powerful minty smell. The essential oil derived from the whole plant will have higher camphor content and lower quality than that distilled from the flower tops. Rosemary essential oil should be stored in a cool, dry area, tightly capped, and kept in the refrigerator once the container has been opened. The oil is stored in glass bottles that are preferably amber coloured. The product should not be exposed to light

or heat, or come into contact with any metals (Datiles and Acevedo-Rodríguez, 2014). A month later weeding nut boiling mud. 4 or 5 times per year need deadheading. The solution of 3 percent to 5 times a year Panchagavya foliar spray to spray at 10 days interval. Tacakavya 3 percent solution is to spray 3 times per year. Vermi compost 10 percent distilled water solution 3 times per year with a foliar spray to spray on a monthly interval (Mahr, 2025). Drying and Storage: To dry rosemary, bundle freshly harvested sprigs and hang them upside down in a warm, dry, and well-ventilated area. Once dried, strip the leaves from the stems and store them in an airtight container away from direct sunlight. Rosemary can also be frozen or used fresh in culinary and medicinal applications (Rana and Singh, 2024).

Diseases: Proper field management is essential to prevent the occurrence of diseases and pests. These includes; weed control, taking care not to retain excessive moisture in the field. Overgrown branches hamper air circulation by reducing the space between plants and creat a suitable environment for diseases and pest occurrence. Thus, regularly cut overgrown branches to make sure that there is enough space between plants for air circulation. Disease and pests can occur and attack rosemary plants at any stage of development. Hence, regular and careful monitoring of rosemary field for signs and symptoms of disease and pest occurrence and careful assessment of the damage level is crucial. Remove diseased branches immediately to minimize the risk of spread. In case of severe infestation take the necessary control measures immediately in consultaion with crop protection experts. Most common disease of rosemary is powdery mildew. Whereas, mealy bugs and cushion scale insect are known to be common pests of rosemary (Kassahun *et al*., 2016).

Fusarium wilt: symptoms of Fusarium wilt are dependent on several factors, including the amount of inoculum in the soil, environmental conditions, nutrients (particularly nitrogen), and susceptibility of the host. Wilting is followed by a yellowing of the leaves and finally necrosis. The wilting generally starts with the older leaves and progresses to the younger foliage. Initial symptoms often occur as the plant is beginning to vine and wilting may occur in one runner on a plant may wilt and collapse, with the rest of the runners remaining healthy. Crop rotation is generally not totally effective because chlamydospores survive so long in the soil and the pathogen can survive in or on the roots of symptomless carrier plants. Soil fumigation with a broad-spectrum biocide provides good initial control; Exclusion of the pathogen is one of the best means of disease control. Use disease-free planting material and disease resistance Varity (Kassahun et al., 2016).

Powdery mildew: the symptom of the diseases is an appearance of ash like white powders spread on the leaves. The disease occurs when soil moisture is excessive, air circulation is poor, humidity is high and shady conditions exist. If the diseases occur, cut overgrown branches to ensure better air circulations, allow the soil to dry out between watering sessions and minimize the amount of water application (Kassahun et al., 2016).

Root Rot: the symptoms of the diseases are wilting of leaves followed by dieing of the whole plant and rotting of the roots. The disease can occur due to excessive moisture in the rosemary field as a result of poor drainage of soil having a high clay content, excessive application of fertilizers can also be a cause. If the diseases occur, minimizing the amount of irrigation, not applying fertilizers, discarding all affected herbs, including the surrounding soil can be helpful minimize the spread and the damage that can be caused by the disease (Kassahun et al., 2016). Although rosemary resists most diseases, some cases of powdery mildew have been reported. Other possible diseases include aerial blight, bacterial leaf spots, and root rots. To prevent a disease from spreading, check the plants regularly and apply the proper fungicides when needed. You can reduce the incidence of diseases by pruning overgrown plants to improve air circulation within them. Pruning also stimulates the production of new shoots (Masabni and Gu, 2025).

Rosemary is generally a resilient plant but can be affected by a few pests and diseases if not properly cared for. Fungal diseases like powdery mildew, which appears as a white, powdery substance on the leaves, can be caused by high humidity or poor airflow. Prevent this by ensuring proper sunlight and good air circulation around the plant. Root rot is another concern, typically caused by overwatering or poorly-drained soil, which leads to decaying roots. To avoid this, ensure your rosemary has well-draining soil and avoid excessive watering (Shibily, 2025). Root Rot: Rosemary is susceptible to root rot in poorly drained soils or when overwatered. Ensuring proper drainage and allowing the soil to dry out between watering can prevent this issue. Frost Damage: In cold regions, frost can damage or kill rosemary plants. To protect them, use frost covers or grows the plants in containers that can be moved indoors during winter (Rana and Singh, 2024).

Insects: Rosemary is fairly resistant to pests. If spider mites, mealy bugs, or scales do appear, you may use any organic or inorganic insecticide that is labeled to treat them. If the plant has scales, an easy solution is to clip off and discard the infested plant tips; scales are sedentary insects. For mealy bugs, spray the plants with water, pyrethrum soap, or a soap-based insecticide. Insects that suck plant sap are generally more prevalent in areas where too much nitrogen fertilizer has been applied. You can avoid most insect problems by fertilizing Properly (Masabni and Gu, 2025). In terms of insects, rosemary is often targeted by aphids, spider mites, and whiteflies. Aphids suck sap from the plant, leading to stunted growth and curled leaves, while spider mites cause yellowing and speckling. Whiteflies can also cause yellowing and weaken the plant. To combat these pests, use insecticidal soap or neem oil, or spray them off with a gentle stream of water (Shibily, 2025).

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