



# **A Comprehensive Study of Rosemary (*Rosmarinus officinalis* L.) Leaf: Its Botanical Properties, Chemical Composition, and Potential Applications**

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## **ABSTRACT :**

This study focuses on botanical characteristics, chemical composition, medicinal properties, and agricultural potential of leaves of *Rosmarinus officinalis*. Rosemary is widely known, a Mediterranean herb plant, widely used for various purposes ranging from culinary practices to medicines for centuries. The bioactive compounds in rosemary's leaves include essential oils, flavonoids, phenolic acids, and other antioxidants that cause its therapeutic actions. This paper 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. The paper further discusses the agricultural potential of rosemary, detailing its ideal growing conditions, pest management, and the challenges it poses in cultivation. Additionally, the paper provides an overview of the applications of rosemary in pharmaceuticals, cosmetics, and food. This study addresses the safety issues and toxicity related to rosemary, especially at high concentrations or for certain individuals. In conclusion, this research establishes the importance of rosemary as a valuable herb with a vast potential in terms of therapeutic and commercial applications while indicating areas to be explored for the full benefit of its application.

**Keywords:** Rosemary leaves, Essential oils, Antioxidant.

## **1. Introduction :**

Rosemary (*Rosmarinus officinalis*) 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.

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.

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.



**Fig. 1 - Rosemary Leaves.**

### 1.1 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.

## 2. Botanical Characteristics of Rosemary :

### 2.1 Scientific Classification

Table 1 - Taxonomic Classification of Rosemary (*Rosmarinus officinalis*)

Taxonomic Classification of Rosemary ( <i>Rosmarinus officinalis</i> )	
Taxonomic Rank	Classification
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Lamiales
Family	Lamiaceae
Genus	Rosmarinus
Species	<i>R. officinalis</i>

### 2.2 Morphological Features of Rosemary Leaves

- Leaves and stems**

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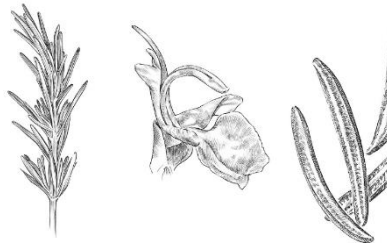


Fig. 2 - Leaves and stems of Rosemary. [2]

- Flowers**

Rosemary flowers are pale violet, white or light blue and pinkish in color. The flowers grow in twos 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.



Fig. 3 - Rosemary.

### 2.3 Distribution and Habitat

It is native to the Mediterranean region, rosemary has naturalized throughout much of Europe and is grown widely in gardens in warm climates.

## 2.4 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 25°C, 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.

**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.

## 3. Chemical Composition of Rosemary Leaves :

### 3.1 Cultivation and Harvesting Practices

The extract is produced mainly from the leaves. Solvents used for extraction include: ethanol, acetone and hexane, and extraction by means of supercritical CO<sub>2</sub> is also popular. Extracts contain considerable amounts of biologically active substances, e.g. phenolic acids, flavonoids, terpenes. Among the phenolic acids in rosemary extract, researchers have managed to isolate caffeic acid, 4-hydroxybenzoic acid, p-coumaric acid, and rosmarinic acid (0.14 mg/g). They also detected some flavonoids: luteolin (0.26 mg/g), apigenin (0.45 mg/g), diosmetin (0.21 mg/g), hispidulin and hesperidin (0.36 mg/g). Along with di- and triterpenes they have also isolated: carnosic acid (128.15 mg/g), oleanic acid, ursolic acid, carnosol (30.08 mg/g), rosmanol (1.25 mg/g), rosmaridiphenol, betulin, picrosalvin,  $\alpha$ -amyrin and  $\beta$ -amyrin. The biological effects of rosemary depend largely on the composition of its essential oil, which is therefore described separately in an analysis of the composition of the volatile oil fraction.

### 3.2 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:  $\alpha$ -pinene,  $\beta$ -pinene, 1,8-cineole, camphene, borneol, camphor, linalool, and  $\beta$ -caryophyllene. Major constituents included:  $\beta$ -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:  $\alpha$ -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.

### 3.3 Methods of Chemical Extraction and Analysis

#### ➤ Essential oil extraction

**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 80°C 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.

- **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 4°C 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.
- **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.

#### 4. Medicinal Properties of Rosemary Leaves :

Rosemary 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.

##### Rosemary has more health benefits, such as:

- 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 Reliefement

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.

#### 5. Agricultural Potential and Challenges in Rosemary Cultivation :

##### 5.1 Ideal 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.

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## 6. Applications of Rosemary Leaves in Various Industries :

### 6.1 Beauty and Cosmetics

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.

### 6.2 Ideal Growing Conditions

Rosemary's pretty, purple flowers often feature in ornamental garden displays. It thrives in containers and along sunny borders in dry regions.

### 6.3 Ideal Growing Conditions

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.

### 6.4 Ideal Growing Conditions

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.

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## 7. Conclusion :

In conclusion, the study of *Rosmarinus officinalis* leaves shows that this herb is very valuable in a variety of fields, such as medicine, agriculture, and industry. The chemical composition of the leaves of rosemary is essential oils, phenolic compounds, and antioxidants that are the basis for medicinal properties, which include anti-inflammatory, antimicrobial, cognitive-enhancing, and digestive health benefits. Historically used for their medical purposes, modern scientific evidence has proven the therapeutic uses of rosemary. Additionally, rosemary is an excellent crop in terms of its agricultural potential. With suitable cultivation practices and sustainable farming methods, the crop can be increased significantly while producing quality. The major limitations would still lie with pest management and environmental conditions. Rosemary is widely used in pharmaceuticals, cosmetics, and food industries, and it has great commercial value, though its toxicity in some populations is a safety concern. Future research should focus on refining cultivation methods, investigating new therapeutic uses, and exploring innovative applications in various industries. Overall, rosemary leaves hold the potential to improve human health and contribute to economic growth but require further studies to unveil the full spectrum of its benefits.

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