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## Review Article

# ***Rosmarinus officinalis* L.: An update review of its Photochemistry and Pharmacological Study**

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## ABSTRACT

Rosemary (*Salvia rosmarinus*), previously known as *Rosmarinus officinalis*, is a fragrant, evergreen herb belonging to the Lamiaceae family, native to the Mediterranean region. For centuries, it has been valued for its culinary, medicinal, and ceremonial uses. Rich in essential oils, polyphenols, and flavonoids, rosemary's key chemical constituents include camphor, 1,8-cineole,  $\alpha$ -pinene, and rosmarinic acid, which are responsible for its characteristic aroma and therapeutic benefits. The herb demonstrates various pharmacological activities such as antioxidant, antimicrobial, anti-cancer, hepatoprotective, anti-diabetic, antidepressant, and anti-inflammatory effects. These properties are largely attributed to active compounds like carnosic acid, carnosol, and ursolic acid. Rosemary's extracts help regulate oxidative stress, enhance apoptosis, improve neurotransmitter function, and inhibit microbial growth, making it effective for treating conditions like cancer, liver disorders, diabetes, and depression. It also plays a role in food preservation by preventing lipid oxidation and bacterial contamination. Recently, rosemary was reclassified from the *Rosmarinus* genus to *Salvia* due to its genetic similarity with other species in the group. As interest in natural therapies grows, rosemary remains a promising candidate for both medicinal and health-related applications.

## INTRODUCTION

Rosemary (*Rosmarinus officinalis*) is an aromatic, evergreen herb belonging to the Lamiaceae family, commonly used in culinary practices and traditional medicine. Native to the Mediterranean region, rosemary has gained global recognition for its diverse applications, including its therapeutic

potential due to its bioactive compounds such as polyphenols, flavonoids, and essential oils. Rosemary is a powerful herb that originates from the Mediterranean region. The original family name is Labiatae because the flowers typically have petals fused into top and bottom lips, although currently most botanists use the name

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Lamiaceae. *Rosmarinus officinalis* is one of the oldest Mediterranean shrubs with powerful pungent aroma and dark green elongated leaves and white or purple flowers. The rosemary herb was used as a food seasoning and natural medicine for over a million years.<sup>[1]</sup> Rosemary, a versatile herb, is widely recognized globally, with various regional names reflecting its cultural significance. Known as merino in Ethiopia, Romero in Spain, Rosmaninho in Portugal, Mehendi in India, Rosmarin in Germany, Romarin in France, and Mi

Die Xiang in China, this fragrant herb has a unified scientific identity, *Salvia rosmarinus*, transcending linguistic and geographical boundaries.<sup>[2]</sup> Rosemary has demonstrated various pharmacological benefits, including antibacterial, anticancer, antidiabetic, anti-inflammatory, antioxidant, antithrombotic, antiulcerogenic, cognitive enhancement, antidiuretic, and hepatoprotective effects. Additionally, its essential oils are valued in the perfumery industry as natural fragrance ingredients.<sup>[3]</sup>



**Fig.1: *Rosmarinus officinalis***

## HISTORY

The name "rosemary" comes from the Latin words "ros" meaning dew and "marinus" meaning sea, translating to "dew of the sea." The ancient Greeks also called it "antos," meaning "the flower," or "libanotis" due to its incense-like scent. Around two thousand years ago, rosemary was introduced to European countries like Britain, Greece, and Italy. In 2001, it was named Herb of the Year by the International Herb Association. Rosemary was introduced to Britain by the Romans and is commonly used in Italian and British cooking today. In ancient Greece and Rome, it was believed to improve memory, earning it the title "herb of remembrance." It was a key ingredient in Renaissance apothecaries and was recommended by Hippocrates, Galen, and Dioscorides for liver issues. In India, rosemary is not widely popular and was introduced as a garden plant by Europeans for its fragrant leaves.

Rosemary, a versatile aromatic plant from the Lamiaceae family, is well-known for its leaves and essential oil. It goes by various names in different countries, such as merino in Ethiopia, Romero in Spain, rosmaninho in Portugal, mehendi in India, rosmarin in German, romarin in French, and mi die xiang in China. Despite these local names, rosemary has historically been recognized by its scientific name, *Rosmarinus officinalis*, a naming system introduced in the 1700s by Swedish naturalist Carl Linnaeus. The Latin name "Rosmarinus" translates to "dew of the sea," likely referring to its ability to thrive near coastal areas and in ocean mists.<sup>[26]</sup> However, recent DNA analysis has prompted a change in its classification, with *Rosmarinus officinalis* now recognized as a synonym of *Salvia rosmarinus*. This shift reflects the plant's reclassification from the genus *Rosmarinus* to the larger genus *Salvia*. While the plant has had different names across

regions due to language variations, its binomial name, used by scientists and researchers globally, remained constant until this recent update.<sup>[4]</sup>

### Origin

Rosemary, known for its genetic diversity, is believed to have originated in the western Mediterranean region. It has been cultivated since ancient times for ornamental purposes, both as a landscape plant and a potted crop, as well as for its

leaves and essential oils in their study on rosemary's demographic expansion, identified various migration routes, including a northern path along the northern Mediterranean coast and two southern routes: one extending from west to east across North Africa to Cyrenaica, and another from the southwestern Iberian Peninsula back to south-central regions.

**Table 1: Geographical Distribution**

| Species                                             | Botanical Origin          | Geographical Distribution                                          |
|-----------------------------------------------------|---------------------------|--------------------------------------------------------------------|
| Salvia Rosmarinus (Formerly Rosmarinus Officinalis) | Mediterranean Rosemary    | Western Mediterranean: - Basin, Spain, Italy, Greece, North Africa |
| Salvia jordanii                                     | Jordan Rosemary           | Eastern Mediterranean: - Jordan, Israel, Lebanon                   |
| Salvia granatensis                                  | Granada Rosemary          | South eastern Spain, Sierra, Nevada region                         |
| Salvia Libanotica                                   | Lebanese Rosemary         | Middle East: - Lebanon, Syria, Palestine                           |
| Salvia heterophylla                                 | Variable leaved Rosemary  | Central and southern parts of Spain, Portugal                      |
| Salvia Lavandulifolia                               | Spanish lavender Rosemary | Southern France                                                    |

### Plant Profile

The rosemary plant is an aromatic, woody, perennial shrub with fragrant, needle like, evergreen leaves. It is part of the mint family, Lamiaceae, and grows upright, reaching heights of up to 2 meters. Its leaves remain green throughout the year, measuring between 2-4 cm in length and 2-5 mm in width. The upper side of the leaves is green, while the underside is white, covered with dense, short, woolly hairs. Different rosemary varieties exhibit differences in leaf size, branching habits, and flower colour, which can range from white, pink, purple, to blue. These botanical variations lead to differences in herbal yield, oil production, and chemical composition across the varieties.<sup>[27]</sup>

### Scientific Classification

**Table 2: Scientific Classification**

|              |                 |
|--------------|-----------------|
| Kingdom      | Plantae         |
| Sub kingdom  | Tracheobionta   |
| Division     | Tracheophyta    |
| Sub division | Spermatophytina |
| Class        | Magnoliopsida   |
| Sub Class    | Asteridae       |
| Order        | Lamiales        |
| Family       | Lamiaceae       |
| Genus        | Rosmarinus      |
| Species      | R.Officinalis   |

### General Characteristics

Rosemary (*Rosmarinus officinalis*) is an aromatic, evergreen shrub that grows up to 2 meters tall. Its stems are slightly four-sided with fine grey hairs. The leaves are narrow, leathery, and dark green on top, with a white, felt-like underside. When crushed, they release a strong fragrance.

The flowers grow in small clusters along the branches, either pale blue or white, with a tubular



shape and two distinct lips. The plant has two prominent stamens, while the others are reduced to tiny staminodes. Its fruit consists of four smooth, small nutlets about 2 mm long.

#### Vernacular Names:

- Sanskrit - Satapatri, Satapatrika, Rusmari
- Hindi - Gul mehandi
- Latin - Rosa damascene
- English - Persian rose
- Tamil - Marikkolundu
- Malayalam - Poovaamkurunthal
- Telugu - Davanamu vanti vokka chettu.

#### Macroscopic characteristics:

##### 1. Leaves:

Linear, needle-like leaves, about 2-4 cm long. Dark green on the upper surface and pale green to whitish on the underside due to dense hairs. Texture is Leathery, tough, and slightly curved at the edges. Smell is Strongly aromatic when

crushed, releasing a characteristic fresh, woody, and pine-like scent.

##### 2. Stem:

Shape of plant is woody and branched. Colour is initially green when young, becoming brown and woody with age. Texture is Rough bark with a fibrous appearance.

##### 3. Flowers:

Pale blue to white or light purple. Shape is bilabiate (two-lipped) with upper and lower lobes. Arrangement of flowers is Small clusters that appear in the leaf axils. Flowering season is blooms throughout the year, particularly in spring and summer.

##### 4. Fruits:

Small, dry nutlets. Shape of fruit is Ovoid, about 1-1.5 mm long. colour of fruit is brown to black.

##### 5. Roots:

Woody tap root system. Texture of fibrous with some thickened woody portions near the base of the stem.<sup>[5]</sup>

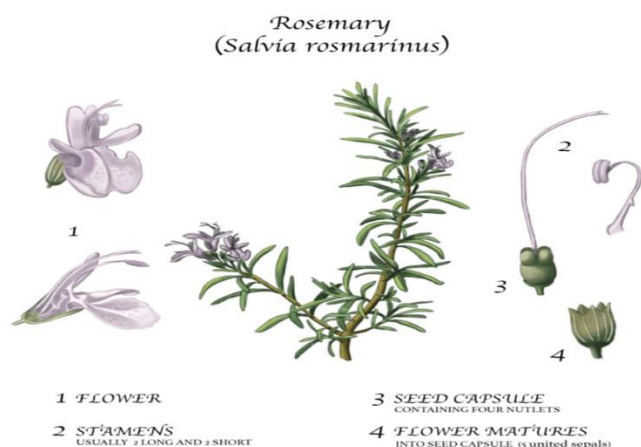


Fig.2: Parts of *Rosmarinus officinalis*

#### Microscopic characteristics:

##### 1. Epidermis:

##### Upper Epidermis:

The upper epidermis is covered with a thick cuticle, consisting of a single layer of polygonal cells.

##### Lower Epidermis:

Presence of abundant non-glandular trichomes (unicellular or multicellular), as well as glandular trichomes with a globular head.

##### 2. Stomata:

Stomata are mainly found on the lower epidermis and are of the diacytic type (two subsidiary cells surrounding the guard cells).

##### 3. Trichomes:

##### Non-glandular Trichomes:

Long, unicellular, and multicellular, covering the surface of both leaf and stem, especially abundant on the lower epidermis.

#### **Glandular Trichomes:**

Glandular trichomes are capitate with a multicellular stalk and a globular head.

#### **4. Vascular Bundles:**

Vascular bundles are collateral and are located in the midrib region. The xylem is located on the upper side, and the phloem on the lower side. The vascular tissue is surrounded by a sclerenchymatous bundle sheath, which provides support.

#### **5. Calcium Oxalate Crystals:**

Calcium oxalate druses are commonly found in the mesophyll tissue. These appear as star-shaped crystals, distributed within the parenchyma cells of the leaf and stem.<sup>[4]</sup>

#### **Types Of Species of Rosemary:**

- 1. Upright Rosemary (*Rosmarinus officinalis*):**  
This variety can spread between six to eight feet in diameter and stands over two feet tall.
- 2. Creeping Rosemary (*Rosmarinus officinalis* 'Prostratus'):** A fast-growing type, it covers eight to ten feet in diameter, with stems that trail downward, reaching the ground, extending up to ten feet.
- 3. Pine-Scented Rosemary (*Rosmarinus officinalis* 'Pine-Scented'):** Recognized by its soft sea-green foliage, it grows to a height of three to four feet and spreads more than four feet wide.
- 4. Arp Rosemary (*Rosmarinus officinalis* 'Arp'):** Ideal for cold climates, this variety thrives in areas where winter temperatures frequently drop to the teens or below.
- 5. Pink Rosemary (*Rosmarinus officinalis* 'Majorca Pink'):** This variety has the narrowest leaves among all *Rosmarinus officinalis* varieties, grows quickly to a height of two feet, and has pale-coloured flowers.

- 6. White Rosemary (*Rosmarinus officinalis* 'Albus'):** A visually striking variety with thick succulent leaves and white flowers that have a hint of blue in the throat. The branches are candelabra-like, giving the plant an airy, open appearance.
- 7. Golden Rain Rosemary (*Rosmarinus officinalis* 'Golden Rain'):** This variety features drooping foliage that turns golden during cooler weather and shifts to a darker green in summer.
- 8. Blue Boy Rosemary (*Rosmarinus officinalis* 'Blue Boy'):** The smallest rosemary variety, with tiny leaves and small, light blue flowers. It covers about 12 inches and rarely grows over six inches tall.
- 9. Spice Islands Rosemary (*Rosmarinus officinalis* 'Spice Islands'):** This variety has thick, juicy-looking leaves, upright growth, and deep blue flowers.<sup>[6,33]</sup>

#### **Health Benefits Of Salvia Rosmarinus Plant**

##### **• Improves Digestion:**

Rosemary has used to treat digestive issues, and its effects on bile production can aid in fat digestion.

##### **• Reduces Inflammation and Pain:**

Anti-inflammatory compounds such as carnosic acid and rosmarinic acid in rosemary help reduce inflammation and alleviate pain.

##### **• Improves Circulation and Heart Health:**

It may help reduce blood pressure and improve circulation, supporting cardiovascular health

##### **• Improve hair and scalp health:**

Rosemary promoting hair growth and scalp health.

##### **• Supports Respiratory Health:**

Rosemary oil relieve congestion and respiratory problems like colds and bronchitis

##### **• May Reduce Anxiety and Stress:**

Rosemary is commonly used in aromatherapy to relieve stress.<sup>[16]</sup>

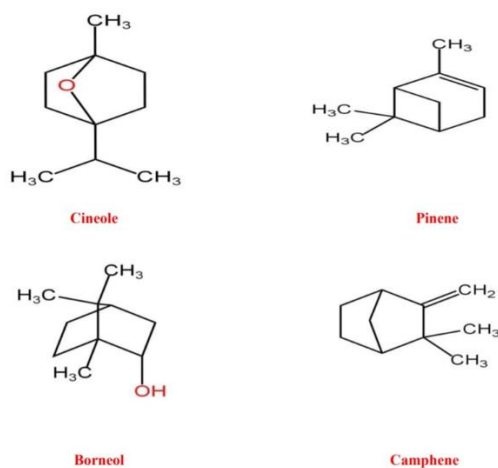
#### **Chemical Constituents:**

The distinct aroma of rosemary is largely attributed to its main constituents, which include



camphor (5.0–21%), 1,8-cineole (15–55%),  $\alpha$ -pinene (9.0–26%), borneol (1.5–5.0%), camphene (2.5–12%),  $\beta$ -pinene (2.0–9.0%), and limonene (1.5–5.0%). These components can vary based on the plant's growth stage and environmental conditions. In addition to essential oils, the extracts of *Rosmarinus officinalis* (rosemary) are rich in phytochemicals such as rosmarinic acid, camphor, caffeic acid, ursolic acid, betulinic acid, carnosic acid, and carnosol. As a result, rosemary primarily consists of phenolic compounds, di- and triterpenes, and essential oils.<sup>[6]</sup> Traditionally, rosemary leaves have been utilized for their antibacterial properties, carminative effects, and analgesic benefits for muscles and joints. The essential oils and extracts from its flowers and leaves are commonly employed to treat minor wounds, rashes, headaches, dyspepsia, and circulation issues, and are also recognized for their expectorant, diuretic, and anti-spasmodic properties in cases of renal colic. Polyphenols, which are antioxidant compounds responsible for the coloring of fruits, can be classified into phenolic acids, flavonoids, and non-flavonoids. In rosemary, prevalent polyphenols include apigenin,

diosmin, luteolin, genkwanin, and phenolic acids, particularly rosmarinic acid, chlorogenic acid, and caffeic acid. Rosemary also contains terpenes, which are primarily found in its essential oils and resins, with over 10,000 different compounds categorized into mono-, di-, tri-, and sesquiterpenes based on the number of carbon atoms and isoprene units ( $C_5H_8$ ). Notable terpenes in rosemary include epirosmanol, carnosol, carnosic acid, ursolic acid, and oleanolic acid. Carnosic acid can be oxidized to form carnosol and possesses physicochemical, thermal, and photo-labile properties. These issues can be mitigated through supercritical fluid extraction, which operates at low temperatures.<sup>[20]</sup> In 2014, five new compounds were discovered in an ethanolic extract of rosemary: officinoterpenosides A1 and A2 (diterpenoid glycosides), officinoterpenosides B and C (triterpenoid glycosides), and officinoterpenoside D (normonoterpenoid). Among the compounds studied from *R. officinalis*, carnosic acid and rosemary essential oil have shown significant pharmacological potential, highlighting their biological activities and therapeutic applications.



**Fig.3: Structure of chemical constituents**

## Pharmacological Effects

### Anti-oxidant activity

Rosemary extracts possess notable antioxidant properties, mainly attributed to polyphenols such as carnosic acid, carnosol, and rosmarinic acid.

These compounds inhibit lipid peroxidation, neutralize free radicals, and protect cellular membranes by accumulating in fatty tissues. The antioxidant effectiveness increases with higher polyphenol concentrations during the plant's fruiting stages. Research has demonstrated improved lipid stability in meat products when rosemary is included in animal diets, with positive effects observed in poultry, lamb, pork, and cattle. Overall, rosemary's antioxidant potential is widely recognized, but its effectiveness can vary based on application.<sup>[7]</sup>

#### **Anti-Microbial activity**

Rosemary has exhibited antimicrobial properties across various food applications. Studies have confirmed its antibacterial effect in products such as beef meatballs, cooked beef, and pork sausage. Additionally, rosemary essential oil has demonstrated activity against multiple pathogens, including *Escherichia coli*, *Bacillus cereus*, *Staphylococcus aureus*, *Clostridium perfringens*, *Aeromonas hydrophila*, and *Salmonella choleraesuis*. When integrated into meat, the essential oil also inhibited the growth of *Brochothrix thermosphacta* and *Enterobacteriaceae*.<sup>[8]</sup>

#### **Anti-proliferative Activity**

Rosemary's crude ethanolic extract has shown selective anti-proliferative effects on different cancer cell lines, particularly human leukemia and breast carcinoma cells. Studies reported that the rosemary extract inhibited cell growth at varying concentrations, with the half-maximal inhibitory concentration. The bioactive compounds in rosemary, such as carnosic acid, rosmarinic acid, and ursolic acid, contribute to these effects by inducing apoptosis, disrupting the cell cycle, and modulating oxidative stress. These properties highlight the potential of rosemary as a natural therapeutic agent in cancer treatment and prevention.<sup>[9,10,11]</sup>

#### **Hepatoprotective Activity**

The aqueous extract of Egyptian rosemary has demonstrated protective effects against liver damage induced by carbon tetrachloride (CCl<sub>4</sub>) in experimental studies. It mitigated carbon tetra chloride induced hepatotoxicity in rats, likely by neutralizing or preventing the generation of free radicals formed during CCl<sub>4</sub> metabolism. This protective effect is attributed to rosemary's bioactive components, which exhibit antioxidant properties. These compounds help reduce lipid peroxidation, stabilize reactive radicals, and maintain cellular integrity, thereby minimizing liver damage. The ability of rosemary to scavenge free radicals plays a crucial role in preserving liver function and reducing the toxic impact of harmful agents.<sup>[12]</sup>

#### **Anti-cancer Activity**

Rosemary has been widely studied for its anti-cancer properties, showing significant inhibitory effects on the growth of various human cancer cell lines. Key phytochemicals in rosemary, such as carnosic acid, carnosol, and rosmarinic acid, play a pivotal role in promoting apoptosis, potentially by triggering nitric oxide production. Among these, carnosic acid has demonstrated the strongest apoptotic activity. Rosemary's extract has also exhibited anti-tumour effects; for instance, in animal studies, it effectively suppressed skin tumour formation by preventing carcinogens from binding to epidermal DNA. The antioxidant properties of rosemary contribute to its protective role against cancer development by reducing oxidative stress. These promising anti-cancer and anti-tumorigenic activities suggest that rosemary could be a valuable natural agent for cancer prevention and treatment.<sup>[14,15]</sup>

#### **Anti-diabetic Activity**

Diabetes mellitus is a rapidly increasing global health issue. Oxidative stress plays a significant role in diabetes progression, as pancreatic  $\beta$ -cells are particularly susceptible to damage from reactive oxygen species, reducing insulin secretion



and elevating blood glucose levels. As a result, there is growing interest in plant-based antioxidants for diabetes management. Rosemary has emerged as a promising natural agent due to its antioxidant properties, which contribute to anti-diabetic and hypoglycemic effects. The rosemary extract can reduce blood glucose levels in normal, hyperglycemic, and diabetic rabbits. Additionally, it prevents lipid peroxidation and enhances the activity of antioxidant enzymes, leading to improved insulin secretion. Rosemary has also been reported to aid in wound healing, a common complication associated with diabetes. These beneficial effects are attributed to the enhancement of the body's antioxidant defence system.<sup>[13]</sup>

#### **Antidepressant Activity**

Rosemary has shown promising potential as a natural antidepressant in several studies. Many of these investigations used the Tail Suspension Test (TST) and Forced Swimming Test (FST) to assess its antidepressant-like effects in mice. The rosemary extract reduced immobility time, suggesting an improvement in depressive symptoms. Further that rosemary alleviated behaviors linked to depression, such as reduced exploration and anhedonia, in bulbectomized mice. The antidepressant effect of rosemary is believed to involve modulation of the monoaminergic system, enhancing neurotransmitter activity, including dopamine, serotonin, norepinephrine, and acetylcholine. Additionally, rosemary has been shown to increase neurotransmitter levels in the brain, which may explain its mood-enhancing properties. Compounds such as carnosol, betulinic acid, ursolic acid, and polyphenols present in rosemary extract and essential oil are thought to play a key role in its antidepressant activity. Therefore the rosemary could be a valuable plant-based option for managing depressive symptoms.<sup>[16]</sup>

#### **Anti-inflammatory Activity**

Rosemary has exhibited strong anti-inflammatory properties in several studies. Both its essential oil and extracts were shown to significantly suppress leukocyte migration in animal models, reducing the accumulation of white blood cells at the site of inflammation and promoting an anti-inflammatory response. Additionally, rosemary extract inhibited the production of key pro-inflammatory molecules, such as nitric oxide, and suppressed the expression of inflammation-related genes. While compounds like carnosol and carnosic acid play a critical role in these effects, the overall anti-inflammatory activity of rosemary is likely the result of synergistic interactions among various bioactive components. The anti-inflammatory effects of carnosol and carnosic acid are approximately nine times stronger than those of Indomethacin, a well-known anti-inflammatory drug. These highlight the potential of rosemary as a natural alternative for managing inflammation.<sup>[36,37]</sup>

#### **Anti-obesity Activity**

Although only three studies have specifically investigated the anti-obesity effects of *Rosmarinus officinalis* (rosemary), their findings are significant. All three studies reported that rosemary effectively limits weight gain, each highlighting a different mechanism underlying this effect. One study revealed that carnosic acid extracted from rosemary inhibits adipocyte differentiation, thereby reducing adipogenesis and promoting sustainable weight loss. In another study, rosemary extract was shown to prevent weight gain by reducing lipid absorption in the intestines, achieved through the inhibition of pancreatic lipase activity. The third study demonstrated that rosemary extract suppresses lipid synthesis by inhibiting Diacylglycerol Acyltransferase (DGAT), the primary enzyme involved in triglyceride production. Collectively, these findings suggest that *R. officinalis* has



considerable potential as a natural treatment for obesity and related metabolic disorders.<sup>[18,19]</sup>

## CONCLUSION

The current review discussed the pharmacological effects and therapeutic potential of rosemary a promising medicinal plant with wide range of pharmacological activities which could be utilized in several medical applications because of its effectiveness and safety.

Extract used for its antioxidant, anti-inflammatory, and antimicrobial properties, rosemary has applications across medical, culinary, and even cosmetic fields. Rosemary extract is used widely to enhance food flavour and preserve freshness, and its essential oils have become popular in wellness and skincare products.

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