

# A Comprehensive Review of the Bioactive Profile, Extraction Methods, and Health-Promoting Properties of *Rosmarinus officinalis*

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## Abstract

Rosemary (*Rosmarinus officinalis* L.), a perennial shrub native to the Mediterranean region, belongs to the Lamiaceae family and has been used traditionally as both a culinary herb and medicinal plant. Its bioactive profile—rich in phenolic compounds, essential oils, and diterpenes—underpins its antioxidant, antimicrobial, anti-inflammatory, and neuroprotective activities. This review summarizes current knowledge on the phytochemical composition, biological properties, therapeutic potential, and industrial applications of rosemary, drawing on findings from recent studies. Recent pharmacological studies have validated many traditional claims, linking rosemary's health benefits to compounds such as rosmarinic acid, carnosic acid, and carnosol. These molecules have demonstrated potent free radical scavenging and anti-inflammatory effects, prompting increasing interest in their therapeutic and nutraceutical potential.

**Key Words:-** Rosemary , Rosemary oil, Extraction process, Pharmacological uses

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## I. Introduction

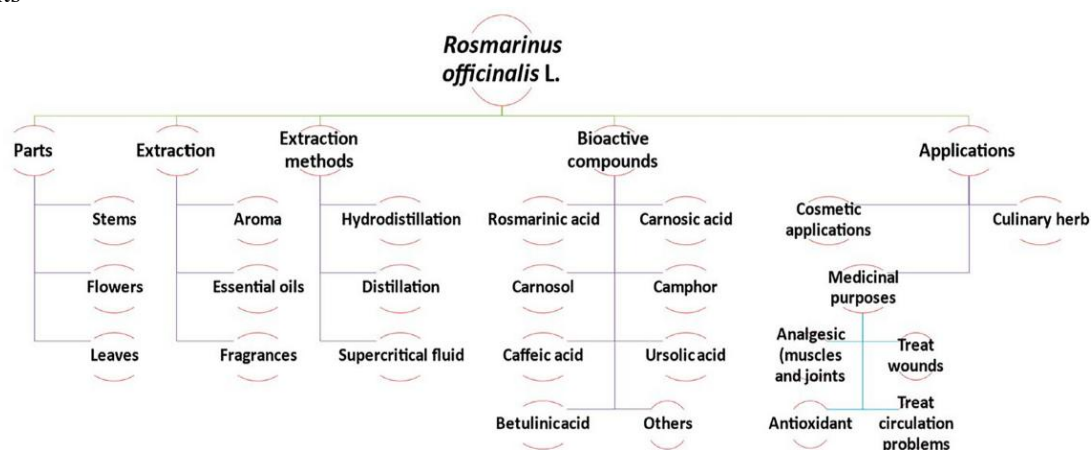
Rosemary (*Rosmarinus officinalis* L.) is a widely recognized medicinal plant known for its diverse pharmacological properties and traditional uses. Its therapeutic effects stem from various phytochemicals, contributing to its roles as an anti-inflammatory, antioxidant, antimicrobial, and memory-boosting agent. The leaf and its oil are commonly used in both food and medicine. Rosemary is an aromatic evergreen herb widely grown for culinary and medicinal purposes.

**Rosemary, known as Rujamari** in Ayurveda, is an aromatic medicinal plant. It is famous for its essential oil that is widely used in the manufacturing of soaps and perfumes. Besides this, it also has ornamental and culinary value. **Rosemary oil** is an essential oil extracted from the leaves of the *Rosmarinus officinalis* plant, known for its aromatic, herbaceous scent and various therapeutic properties. It is used in aromatherapy, hair and skincare, and traditional medicine to improve hair growth, boost cognitive function, reduce stress, and act as an antioxidant and anti-inflammatory agent. It has a history of use dating back to ancient Egypt and has applications ranging from perfumes and cosmetics to food preservation.



## II. Details

Rosemary (*Salvia rosmarinus*, formerly *Rosmarinus officinalis* L.) is an aromatic evergreen shrub native to the Mediterranean region. It has been historically valued for its culinary uses and its extensive applications in traditional medicine. Modern research continues to explore and authenticate its wide range of therapeutic benefits



Rosemary flowers



Rosemary leaves



Dried rosemary leaves



Rosemary oil

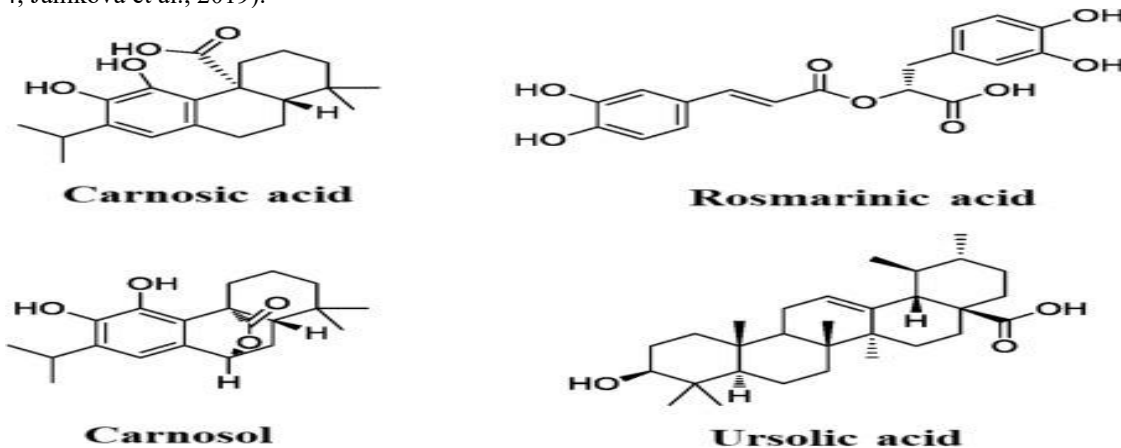
## III. Phytochemical Composition

Rosemary's major bioactive constituents fall into three main categories:

- Phenolic acids: chiefly rosmarinic acid, chlorogenic acid, and caffeic acid
- Diterpenes: carnosic acid, carnosol, and rosmanol—responsible for strong antioxidant activity
- Essential oils: mainly 1,8-cineole, camphor,  $\alpha$ -pinene, and borneol; these contribute to antimicrobial and aromatic properties

The concentration and ratio of these compounds vary with cultivar, growth conditions, extraction methods, and storage.

Phytochemistry Rosemary has the signature scent of camphor. Alpha-pinene (9.0- 26 %), 1,8-cineole (15-55 %), borneol (1.5-5.0 %), camphor (5.0-21 %), camphene (2.5-12 %), b-pinene (2.0-9.0 %) and limonene (1.5-5.0 %) are the major constituents of rosemary essential oil. This composition fluctuates according to the bioclimatic circumstances and vegetative stage (Peru Checklist, 2014). The primary phytochemicals found in *R. officinalis* are comprised of rosmarin, ursolic acid, caffeic acid, camphor, carnosic acid, and carnosobetulinic acid (Royal Botanic Garden Edinburgh, 2014; Carrubba et al., 2020). To summarize, *R. officinalis* comprises predominantly of phenolics pertaining to di- and triterpenes compounds and essential oils (Royal Botanic Garden Edinburgh, 2014; Janikova et al., 2019).



**3.1 Composition of *R. officinalis* essential oils:-** The amount of essential oil that can be obtained from rosemary is a reflection of the extraction procedure which has been implemented in the form of supercritical CO<sub>2</sub> or hydro distillation extraction. The variation might also arise from the plant age and the harvest season. The volume of the essential oil is normally expressed in terms of 10 mL/kg of the dry plant. The chief monoterpenoids are 1:8-cineole, a-pinene, camphor with minor quantities of monoterpenoids such as limonene, p-cymene, camphene, borneol, and terpineol. Recently, various gas mass spectroscopic analyses of rosemary essential oil have been studied across Morocco, Italy, Tunisia, Spain, Brazil, and Balkans. About 75 phytochemicals have been detected so far. Some phytoconstituents are significant chemotypes that comprise a-pinene predominate, cineole, or camphor. Successive biosynthetic trials by other plants developed an arrangement through the tertiary linalool diphosphate cyclization. In the essential rosemary oil, only small quantities of humulene, caryophyllene, and cedrene harbored some oxygenated components like caryophyllene oxide. Terpenes, typically found in essential oils and resins are classified into mono, di, tri and sesquiterpenes are important constituents of more than 10,000 bio-natural compounds. Rosemary terpenes such as carnosol, oleanolic acid, carnosic acid, ursolic acid, and epirosmanol were reported. However, carnosic acid which is eventually oxidized into carnosol has photolabile, physicochemical, and thermal properties.

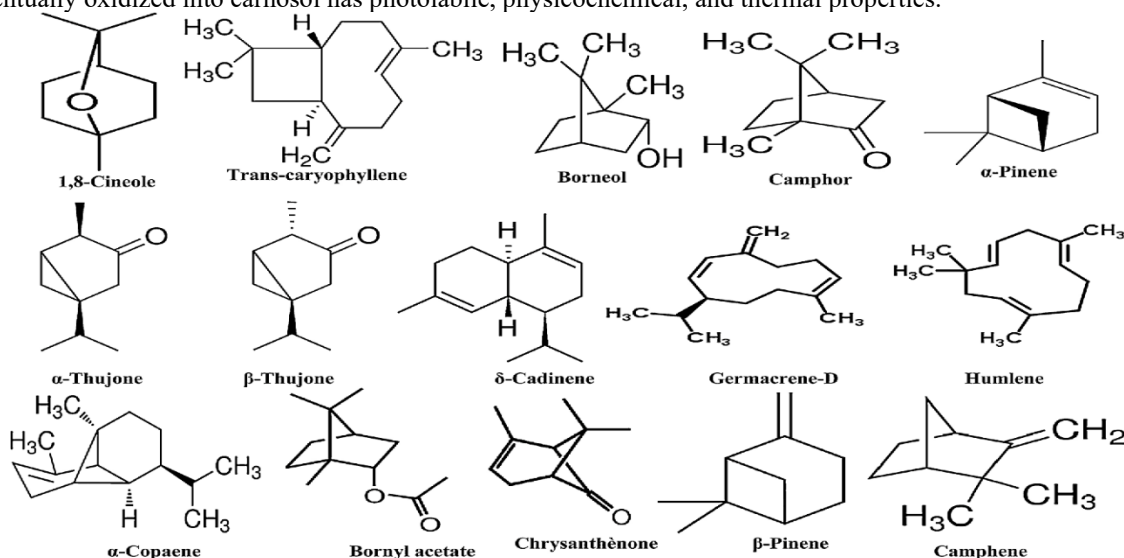
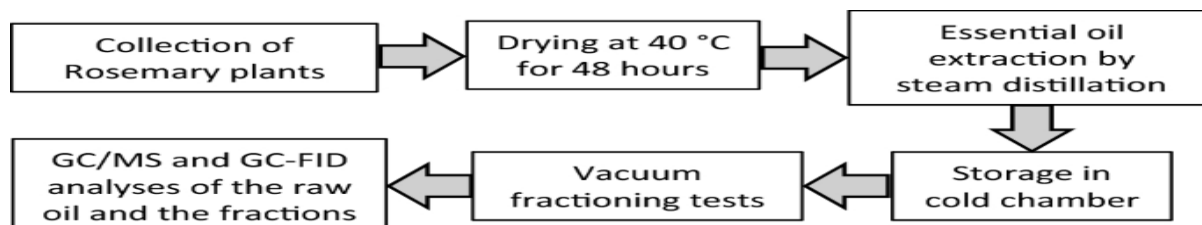


Fig. 1. Structures of chemicals components of ROEO.

#### IV. Extraction of essential oil

The experimental set-up for the extraction of essential oils from *Rosmarinus officinalis* L. using steam distillation. It was composed of four elements such as boiler, extraction chamber, condenser, and separator. The extraction chamber was made of a vessel in which the steam interacts with leaves and vaporize the oils. First, leaves were fed into the extraction chamber before starting the process. To avoid the channeling effect, the maximum packing was ensured in the chamber. On the other hand, there could be a possibility of low yield if the effect persists. A coil flow condenser was used to convert the steam and oil vapors into liquid. To separate water from oil, the water layer was drained out by opening the tap till the meniscus was just above the calibration mark.



#### V. Pharmacological Properties

##### 5.1 Antioxidant Activity

Rosemary extracts exhibit significant antioxidant potential through both enzymatic and non-enzymatic pathways. Carnosic acid and rosmarinic acid are effective in neutralizing reactive oxygen species (ROS) and inhibiting lipid peroxidation, making rosemary valuable in food preservation and anti-aging formulations.

##### 5.2 Antimicrobial and Antifungal Effects

The essential oils of rosemary have broad-spectrum antimicrobial action against *Staphylococcus aureus*, *Escherichia coli*, *Candida albicans*, and other pathogens. The mechanism often involves disruption of microbial cell membranes due to lipophilic terpenoids.

##### 5.3 Anti-Inflammatory and Analgesic Effects

Both aqueous and ethanolic extracts reduce inflammation via inhibition of cyclooxygenase (COX) and lipoxygenase (LOX) enzymes. Animal models show analgesic effects comparable to mild nonsteroidal anti-inflammatory drugs (NSAIDs).

##### 5.4 Neuroprotective Properties

Rosemary's compounds have been shown to attenuate neuronal damage, enhance cognitive performance, and exhibit anti-Alzheimer's potential. Carnosic acid activates the Nrf2 signaling pathway, promoting neuronal resilience against oxidative stress.

##### 5.6 Anticancer Potential

In vitro and in vivo experiments indicate that rosemary diterpenes can induce apoptosis and inhibit tumor growth in colon, breast, and prostate cancer cell lines. Modulation of NF- $\kappa$ B and MAPK pathways appears central to these effects.

##### 5.7 Immune System Support

The carnosic and rosmarinic acids in rosemary have powerful antibacterial, antiviral, and antifungal properties. Consuming rosemary regularly can potentially help lower the risk of infection and help the immune system fight any infections that do occur.

##### 5.8 Improved Memory and Concentration

Rosemary has been used for centuries as a memory aid, and studies in [aromatherapy](#) using rosemary have corroborated some of these claims. One study found significant improvements in cognitive performance within 20 minutes of inhaling rosemary essential oil.

##### 5.9 Nutrition

Rosemary is especially rich in phytochemicals. While phytochemicals aren't essential for survival like vitamins and minerals are, they are nevertheless important for fighting disease and maintaining overall health.

The phytochemicals in rosemary may help to improve eye health, regulate liver function, and lower the risk of asthma.

##### 5.10 Industrial and Therapeutic Applications

Rosemary is utilized in:

- Food industry: as a natural antioxidant and preservative
- Cosmetics: for anti-aging, antimicrobial, and hair-growth-promoting products
- Pharmaceuticals and nutraceuticals: in formulations targeting memory, metabolism, and inflammation
- Aromatherapy and essential oils: for mood enhancement and mild respiratory relief

## VI. Safety and Toxicity

Rosemary is generally regarded as safe in culinary and therapeutic doses. However, excessive intake of essential oils can cause gastrointestinal distress or neurotoxic effects due to high camphor content. Standardization and controlled dosing are crucial for medicinal use.

## VII. Conclusion

Rosemary remains a plant of significant therapeutic interest due to its rich phytochemical profile and broad pharmacological actions. Future research should focus on clinical validation, bioavailability optimization, and identification of molecular targets to harness rosemary's full therapeutic potential.

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