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Review Article

Unveiling The Therapeutic Potential of *Rosmarinus Officinalis* (Rosemary) – A Review on Pharmacological Spectrum

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ABSTRACT

Rosemary (*Rosmarinus officinalis*), a widely recognized herb, has been traditionally used in culinary, medicinal and cosmetic applications. Its unique bioactive compounds, including essential oils, flavonoids, and phenolic acids, have attracted attention for their diverse pharmacological properties. This review article aims to provide a comprehensive overview of taxonomy and medicinal potential of rosemary, focusing on its antioxidant, anti-inflammatory, antimicrobial, anti-diabetic, anticancer and neuroprotective activities. It is used in stimulating hair growth, in preventing chronic diseases such as cardiovascular disorders, neurodegenerative diseases, and cancer. Through this article, we seek to offer a deeper understanding of the therapeutic benefits of rosemary and explore research directions for maximizing its medicinal potential. Rosemary is one of the important aromatic and medicinal plants recognized globally. Rosemary is known having different common name from one country to the another. It is perennial plant from the mint family with ever green leaves. Recently its binomial name reported as *Rosmarinus officinalis* changed to *Salvia rosmarinus*. Rosemary product can be fresh or dry leaf as well as transformed into oils, extracts, and essences. Rosemary comprises different varieties that can be used as fresh herb, dry herb and for essential oil.

INTRODUCTION

Rosemary (*Rosmarinus officinalis*), a plant from the Lamiaceae family, is an evergreen herb that typically grows to about 1 meter tall. It has upright

stems, dark green leaves, and whitish-blue flowers, primarily found in the Mediterranean region. The genus name *Rosmarinus* is derived from two Latin words: “ros,” meaning “dew,” and

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“marinus,” meaning “sea.” Together, they form the phrase “dew of the sea.” This name likely highlights the plant’s natural habitat, as rosemary tends to thrive in coastal areas, often found on sea cliffs and benefiting from the moisture provided by ocean mists [1]. This plant is widely used in both traditional and modern medicine to treat various ailments [2]. Rosemary’s ability to preserve food and provide health benefits comes from its essential oil and extracts. The specific makeup of these compounds can change based on the environment, but all rosemary extracts have active ingredients that set them apart. Key compounds like carnosic acid, carnosol, and rosmarinic acid give rosemary its strong antioxidant properties. These antioxidants not only help preserve food but also contribute to rosemary’s potential health benefits, such as fighting cancer and diabetes. Thus, the powerful antioxidant compounds in rosemary are attracting interest in both the food and medical fields. For centuries, *Rosmarinus officinalis* has been used for flavoring and preserving food, but only recently have scientists begun to explore how it works. Studies have shown that rosemary extracts possess strong antibacterial, antifungal, and antioxidant properties, making the plant effective at preventing foodborne pathogens [3]. Studies on rosemary extracts reveal that its key active compounds include phenolic diterpenes, triterpenes, and phenolic acids, such as carnosic acid, carnosol, rosmanol, ursolic acid, betulinic acid and rosmarinic acid. Additionally, rosemary essential oil contains 10-20% camphor [2]. Due to

their potential health benefits, medicinal plants like rosemary have gained attention for their effectiveness, low side effects, and common use in treating different health issues. It may help increase blood circulation, support digestion, enhance memory, and boost the immune system. These properties make rosemary a popular herb for improving overall well-being [4].

Taxonomy:

- **Synonym:**

Gulmehendi, Keshvas, Dauni.

- **Biological Source:**

Oil of Rosemary is distilled from the flowering tops of leafy twigs of *Rosmarinus officinalis*, belonging to family Lamiaceae.

- **Geographical Source:**

The plant is native to the Mediterranean region, which includes Spain, North Africa. It is now cultivated in many parts of the world, including Europe, North Africa, Middle East, India and United States.

- **Chemical Constituents:**

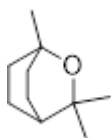
The major components are Eucalyptol also called as 1,8-Cineole (26.54%), α -Pinene (20.14%), Camphor (12.88%), Camphene (11.38%) and β -Pinene (6.95%), respectively.[1]

Also, Carnosic acid (7-7.5%), Caffeic acid (1-3%), Chlorogenic acid, Carnosol & Rosmanol (0.5 - 2%), Oleanolic acid (0.1 - 1.5%), Rosmarinic acid (5 - 10%), Ursolic acid (1 -2%), Luteolin (0.1-0.5%), Apigenin (0.01-0.2%), Borneol (1-2%), Linalool (1-3%) are found in rosemary.

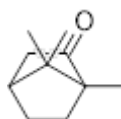
Figure 1: Chemical Constituents with Percentage and Uses.

Chemical Constituents	Percentage	Uses
1,8- Cineole	26.54%	Aroma, Anti-microbial
Alpha-Pinene	20.14%	Aroma, Anti-inflammatory
Camphor	12.88%	Aroma, Analgesic
Camphene	11.38%	Aroma, Anti-oxidant
Beta-Pinene	6.95%	Aroma, Anti-bacterial
Carnosic acid	7-7.5%	Anti-oxidant, Neuroprotective

Caffeic acid	1-3%	Anti-oxidant, Anti-inflammatory
Chlorogenic acid	0.5-2%	Anti-oxidant, Anti-inflammatory, Cardiovascular support
Carnosol	0.5-2%	Anti-oxidant, Anti-cancer, Anti-diabetic
Rosmanol	0.5-2%	Anti-oxidant, Anti-inflammatory
Oleanolic acid	0.1-1.15%	Anti-oxidant, Anti-inflammatory, Anti-cancer
Rosmarinic acid	5-10%	Anti-oxidant, Anti-inflammatory, Anti-microbial
Ursolic acid	1-2%	Anti-oxidant, Anti-inflammatory, Anti-cancer
Luteolin	0.1-0.5%	Anti-oxidant, Anti-inflammatory
Apigenin	0.01-0.2%	Anti-anxiety, Anti-inflammatory
Borneol	1-2%	Aroma, Anti-microbial
Linalool	1-3%	Calming, Sedative



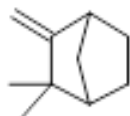
1,8-cineole



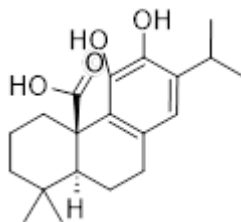
2. Alpha pinene



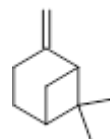
3. camphor



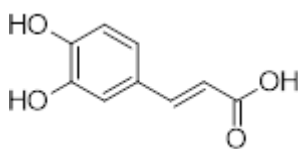
4. camphene



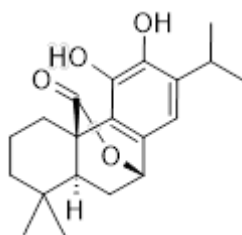
5. beta pinene



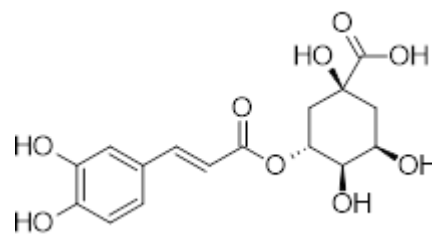
6. Carnosic acid



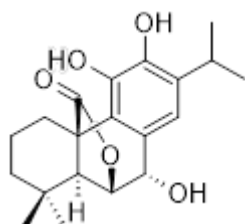
7. Caffeic acid



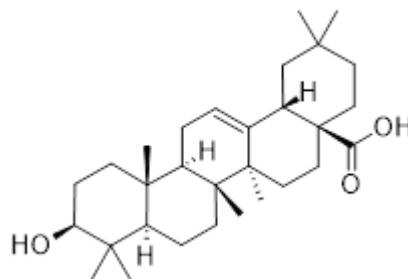
8. Chlorogenic acid



9. Carnosol



10. Rosmanol



11.oleanolic acid

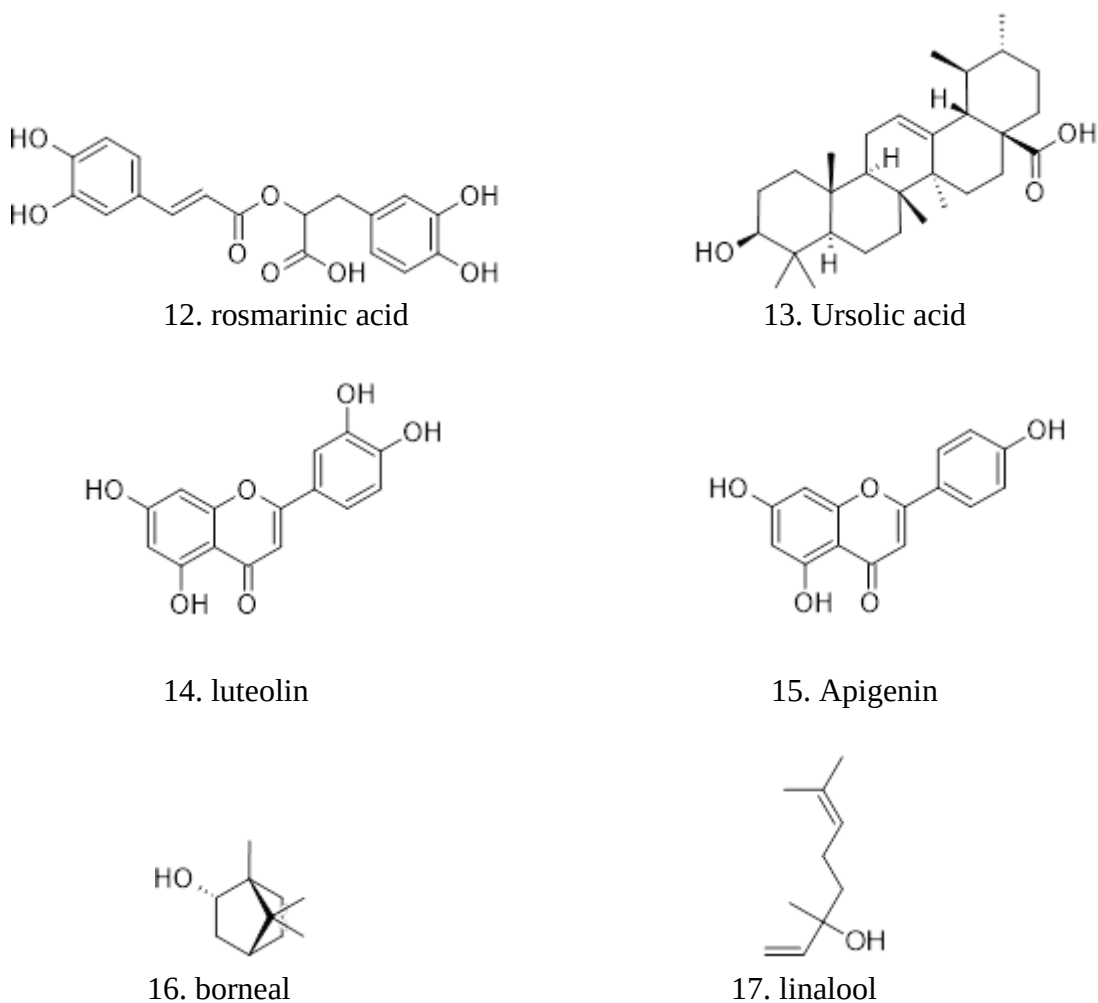


Figure 2. Structure of compounds found in Rosemary

Morphological Characteristics:



Figure 3. Seeds of Rosemary

- **Seeds:**
 - Shape: Seeds are small and oval.
 - Colour: Typically, dark brown to gray in color.
 - Appearance: They have a hard outer shell and can be somewhat fragile.
- Growth requirements: When planted, rosemary seeds require warmth and light for germination, which usually takes 2 to 3 weeks.
- Phytoconstituents: While present in lower concentrations in the seeds, essential oils like

camphor, 1,8-cineole, and borneol can still be found [6].



Figure 4. Stem of Rosemary

- **Stem:**
 - Size: Rosemary is a green, bushy herb that can reach a height of 3 to 6 feet.
 - Odour: It has a distinct smell with hints of camphor.
 - Colour: The upright stems branch out into many long, thin parts and have grayish, rough bark.
 - Phytoconstituents: The chemical constituents found in the stem are a phenolic compound - Rosmarinic acid, a diterpene - Carnosic acid, a diterpenoid phenol- Carnosol & essential oil like 1,8- Cineole [7].



Figure 5. Leaves of Rosemary

- **Leaves:**
 - Growth: The branches have leaves that grow in pairs.
 - Size: The leaves are 1 cm to 4 cm long and 2 mm to 4 mm wide with recurved edges.
 - Shape: These leaves are thick and shiny, with a long shape.
 - Colour: The top side is dark green, while the underneath is gray and has a fuzzy texture.
 - Phytoconstituents: The chemical constituents found in the leaves are Phenolic compound - Rosmarinic acid, A diterpene – Carnosic acid, A diterpenoid phenol – Carnosol and Essential oils such as 1,8-Cineole and Camphor [7].



Figure 6. Flowers of Rosemary

• **Flowers:**

- **Colour:** The flowers are small and can range in color from light blue to dark blue.
- **Protective Part:** A large portion of the fragrant essential oils is found in their outer protective parts, called calyces.

- **Phytoconstituents:** Flowers contain the chemical constituents such as a phenolic compound - Rosmarinus acid, flavonoids – Luteolin and Apigenin and essential oils like Borneol and Linalool [7].

Microscopical Characteristics:

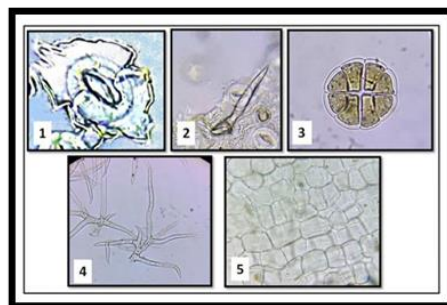


Figure 7. Microscopical Characteristics of Rosemary [7]

1. Pieces of the lower epidermis with wavy-walled cells and many diacytic stomata.
2. Conical covering trichomes (hair-like structures).
3. The typical glandular trichome of the labiate type, which has a short unicellular stalk and a head made of eight cells sharing a common cuticle.
4. Numerous branched covering trichomes that form a dense, felt-like layer. These are multicellular, thin-walled, single-layered, and highly branched.
5. Fragments of the upper epidermis showing cells that are polygonal to irregular in shape, with slightly thickened walls and some pits [7].

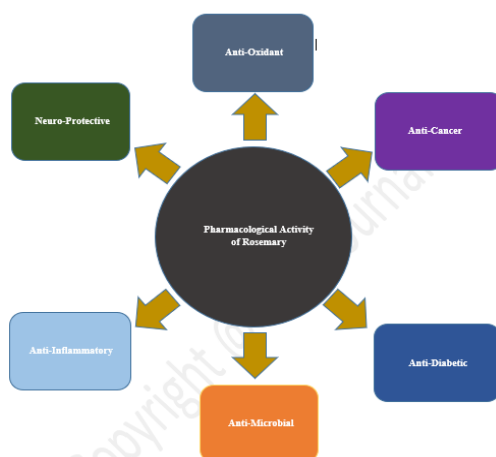


Figure 8. Pharmacological activity of Rosemary

Therapeutic Applications / Pharmacological Activity:

• **Anti-oxidant Activity:**

Polyphenols are compounds found in many plants that are important for both plant health and human well-being [8,9]. They come in various forms, including phenolic acids and alcohols, and have

multiple hydroxyl groups attached to aromatic rings [10]. In our diets, we find polyphenols in foods such as fruits, vegetables, grains, legumes, tea, coffee, and chocolate [11]. The amount and quality of polyphenols in these foods can vary based on factors like the plant's genetics, growing conditions, soil type, maturity at harvest, and how

the food is handled afterward [12]. Polyphenols have antioxidant properties, allowing them to neutralize free radicals, but their effectiveness can vary based on the specific type of compound, its methoxylation level, and the number of hydroxyl groups it has [13]. These antioxidant abilities may help protect against various diseases, including cancer, Alzheimer's, and heart problems [14]. The antioxidant properties of rosemary are primarily linked to the chemical compounds found in its essential oils and extracts. Although the interaction between various oil components likely enhances this antioxidant effect, phenolic diterpenes like carnosic acid, carnosol, and rosmarinic acid have been recognized as the most potent antioxidants in rosemary essential oil [2,15,16].

- **Anti-cancer Activity:**

Cancer develops in three main stages: initiation, promotion, and progression. The initiation stage involves changes to a cell's genetic material that make it susceptible to becoming cancerous. In the promotion stage, various factors allow a single mutated cell to thrive and multiply, leading to the formation of a tumor. As this process continues, the cancer progresses, and the situation becomes more serious as malignant cells proliferate. Research has demonstrated that *Rosmarinus officinalis*, commonly known as rosemary, possesses anticancer properties. Several studies have shown that rosemary can effectively inhibit the growth of different types of human cancer cells. Key compounds found in rosemary, including carnosic acid, carnosol, and rosmarinic acid, have been shown to induce apoptosis in these cancerous cells, contributing to its potential as a cancer treatment [2,17,18,19]. Recent research by Birtić et al. highlights the potential of natural products, like polyphenols, to interact with microtubule affinity regulatory kinase (MARK 4), making them promising candidates for cancer treatment [20]. Notably, polyphenolic antioxidants

can act both as antioxidants and prooxidants, which may lead to the death of cancer cells and damage to biological molecules, especially in the presence of redox-active metals like copper [21].

- **Anti-diabetic Activity:**

Diabetes mellitus is becoming a major health issue worldwide. High oxidative stress often contributes to the development of diabetes, with pancreatic beta cells being particularly sensitive to reactive oxygen species. This vulnerability can result in lower insulin production and increased blood sugar levels [22]. As a result, many new diabetes treatments are exploring the use of natural antioxidants, especially those derived from plants. Research has shown that Rosemary (*Rosmarinus officinalis*) may be a promising option for managing diabetes [23]. Rosemary, known for its antioxidant properties, has shown various effects that can help manage diabetes and lower blood sugar levels. Studies have found that rosemary extract can reduce blood glucose levels in rabbits, whether they are normoglycemic, hyperglycemic, or diabetic. Additionally, the extract promotes insulin secretion by preventing lipid peroxidation and activating antioxidant enzymes. Another serious complication of diabetes is slow wound healing, and rosemary has been shown to help with this issue as well. The beneficial effects of rosemary on blood sugar and healing are attributed to its ability to enhance the body's antioxidant defenses [2].

- **Anti-microbial Activity:**

Many studies have shown that rosemary has strong antimicrobial and antifungal properties. Research indicates that methanol extracts from rosemary can effectively stop the growth of spoilage microorganisms and harmful pathogens, including *Brettanomyces*, *Saccharomyces cerevisiae*, *Candida albicans*, *Bacillus megaterium*, *Staphylococcus aureus*, and *Escherichia coli*. Ojedasana et al. found that 1,8-cineole, a compound in rosemary essential oil, also has



antimicrobial effects. Additionally, Bernarde's research suggests it can prevent the growth of bacteria like *Streptococcus pyogenes* and *Streptococcus salivarius* [24]. Rosemary's antimicrobial qualities may help reduce the resistance of these bacteria to medications by disrupting their cell membranes. Overall, rosemary exhibits powerful antibacterial properties that can be particularly beneficial in food preservation. Compounds in rosemary, such as rosmarinic acid and carnosic acid, have been shown to inhibit the growth of various bacteria and fungi that can spoil food. The antimicrobial properties of rosemary can help slow down spoilage processes, extending the shelf life of perishable products [2,3,17,25].

- **Anti-inflammatory Activity:**

Studies have found that rosemary extracts can lower the levels of certain inflammation-causing proteins, such as tumor necrosis factor alpha (TNF- α), Interleukin-1 beta (IL-1 β), and Interleukin L-6 (IL-6). These proteins are activated by oxidized low-density lipoprotein and lipopolysaccharides in specific immune cells. This suggests that rosemary might be useful for reducing inflammation, mainly because of its key ingredients, rosmarinic acid and carnosic acid [24]. Both rosemary essential oil and extract were found to effectively reduce the movement of white blood cells to inflamed areas, leading to less inflammation. Additionally, rosemary extract was shown to lower the production of substances that cause inflammation, like nitric oxide, and to affect genes related to inflammation. While the compounds carnosol and carnosic acid are particularly important, the overall anti-inflammatory effects of rosemary likely come from the combined action of various components. Research indicates that the anti-inflammatory power of these pure compounds is significantly stronger than that of indomethacin, a widely used anti-inflammatory medication [3].

- **Neuroprotective Activity:**

Rosemary (*Rosmarinus officinalis*) has shown promising effects in protecting the brain from neurodegenerative diseases like Alzheimer's and dementia. It can inhibit two key enzymes, cholinesterase (AChE) and butyrylcholinesterase (BCHE), which break down acetylcholine in the brain. This activity is likely due to compounds such as rosmarinic acid and terpenes found in its essential oil. By increasing acetylcholine levels, rosemary may help reduce symptoms related to Alzheimer's, memory loss, anxiety, and depression. Additional studies further support rosemary's neuroprotective qualities. One study found that the polyphenols in rosemary extract can block stress proteins involved in neurodegeneration. Another study indicated that rosemary boosts levels of nerve growth factor (NGF), a protein essential for nerve growth and maintenance. Higher NGF levels could help with Alzheimer's, dementia, and other neurodegenerative conditions, highlighting rosemary's potential as a protective agent for brain health [3].

- **Promoting Hair Growth:**

Rosemary extract is known to help hair follicles, which can lead to hair growth. When applied to the scalp, rosemary oil improves blood flow and delivers oxygen and nutrients to the hair roots. This can strengthen current hair and encourage the growth of new strands. Research has indicated that rosemary oil can be effective in promoting hair growth, making it a favored option for those wanting to enhance their hair's health and thickness [26,27].

Rosemary oil has several benefits for hair and scalp health:

- Fights bacteria: Its antimicrobial properties help eliminate dandruff and promote a healthy scalp.
- Reduces swelling: The oil calms and reduces inflammation on the scalp.



- Boosts blood flow: Massaging rosemary oil into the scalp can improve blood circulation, which supports hair growth.
- Nourishes hair: The oil contains fatty acids that nourish hair follicles, providing essential nutrients for strong and healthy hair [26,28].

- **Cosmetics:**

Rosemary has been a popular plant since ancient times. The ancient Egyptians used creams and oils made from various plants, including rosemary, to protect against heat and the harsh desert climate. People have always cared about their appearance and sought out cosmetic products, looking for natural and safe options. This interest in using plant-based products stems from a desire for non-toxic solutions. Consumers today demand high-quality personal care items and want scientific evidence to back the claims made on product labels, even if they are not classified as drugs. The

cosmetics industry is responding to this demand, incorporating rosemary, known for its medicinal benefits, into many products. Rosemary extracts can be found in anti-wrinkle creams, aftershaves, hydrating facial creams, essential oils, shampoos, soaps, deodorants, and various other personal care items. Using essential oils in cosmetics has many benefits, like improving product quality and making them more attractive to customers. Research by Khan et al. and Sharif et al. looked at how plant-based creams and other forms can help with aging skin in volunteers. For example, rosemary extracts can help stabilize certain types of mixtures. Microencapsulating these oils protects them from breaking down and allows for controlled release. There are also ongoing projects to create special capsules with rosemary oil to use as an antifungal ingredient in cosmetics [2,29].

Marketed Formulations of Rosemary:



Figure 9. Rosemary Essential Oil

- **Rosemary Essential Oil:**

- Stimulates hair growth.
- Improves scalp health.
- Used in aromatherapy.
- Reduces muscles and joint pain.
- Used in medicines & cosmetics formulations [26].



Figure 10. Rosemary Leaf Powder

- **Rosemary Leaf Powder:**
 - Improve serum lipid profile.
 - Possess hypolipidemic and hypoglycemic properties.
- Lowers blood sugar level.
 - Helps to boost immunity [30].



Figure 11. Rosemary Leaf Extract

- **Rosemary Leaf Extract:**
 - Used as a dietary supplement.
 - Memory enhancement.
- Mood enhancing.
 - Digestive aid.
 - Food preservative [31].



Figure 12. Rosemary Shampoo & Conditioner.

- **Rosemary Shampoo and Conditioner:**
 - Effective hair growth.
 - Works on itchy scalp.
 - Makes hair soft, shine and strong.
- Repairs hair against future damage.
 - Restore hair's moisture levels.
 - Replenishes healthy hair protective layer [26].



Figure 13. Rosemary Anti-wrinkle / Anti-aging Cream

- **Rosemary Anti-wrinkle / Anti-aging cream:**
 - Helps in preventing wrinkles.

- Protection against UV rays.
- Reduces the skin damage.
- Tightens up skin tone.
- Soothes skin irritation [31].



Figure 14. Rosemary Hair Gel.

- **Rosemary Hair Gel:**
 - Improves scalp health.
 - Prevents itching & inflammation.
 - Adds shine & volume to hair.
 - Stimulate hair follicles.
 - Reduces dandruff [26].



Figure 15. Parachute Advanced Rosemary Enriched Coconut Hair Oil

- **Parachute Advanced Rosemary Enriched Coconut Hair Oil:**
 - Makes hair stronger and thicker.
 - Helps reduce hair thinning.
 - Controls hairfall.
 - Provides lustrous hair. [32]

CONCLUSION:

Rosemary, scientifically known as *Rosmarinus officinalis*, shows potential as a natural food preservative and medicinal ingredient. Its low toxicity and strong antioxidant, antibacterial, antidiabetic, anticancer, and antifungal properties make it a safer alternative to artificial additives. Rosemary's essential oil contains over 150 compounds, while the non-volatile part has fewer. Key components include flavonoids, ursolic acid, oleanolic acid, carnosic acid, and rosmarinic acid.

Rosemary may also be effective in cosmetics, helping to prevent spoilage. Further research could clarify how its active ingredients work. We view this plant as a beneficial product for skincare, aiding in maintaining skin health and preventing certain skin issues.

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