



Exploring the Therapeutic Potential of Rosemary: An In-depth Review of its Pharmacological Properties

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Review Article

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ABSTRACT

The pharmacological effects of rosemary plant period a wide range and include anti-inflammatory and antioxidant properties. Rosemary is shown to have its potential on Ischemic stroke because of its Anti-oxidant and Anti-inflammatory properties. It contains strong antioxidants such as carnosol, which has anti-inflammatory properties, and Rosmarinus acid, which fights oxidative stress. Rosemary is an attractive possibility for treating disorders like oxidative-related diseases because of its dual activity. Additionally, Rosemary has shown neuroprotective qualities that aid in maintaining brain health and cognitive function. The aromatic components in its essential oil may improve concentration and memory. Rosemary has also been investigated for its potential in hair care, with research indicating that it can encourage hair growth. These rosemary *Officinalis* also have different chemical substances and compounds like Terpenes, Essential oils, Bicyclic monoterpenes, Monoterpenoids, Ester and also, we have different pharmacological activities they are Anti-oxidative, Anti-inflammatory, Anti-microbial, Anti-obesity, Anti-fungal, Anti-cancer, Anti-diabetic, Cardiovascular activity, Skin health, Neuroprotective, Gastrointestinal, Sperm motility, Anti-depressant, Anti-viral activity.

Keywords: *Anti-microbial; anti-oxidant; biological activities; carnosic acid; phenolic acid; rosmarinic acid; urosolic acid.*

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1. INTRODUCTION

Rosemary (*Rosmarinus officinalis*), an aromatic evergreen herb with blue-violet blooms and fragrant needle-like leaves, is a native of the Mediterranean area. This plant has a lengthy, intricately entwined history that dates back to the dawn of human civilisation. The Latin words "ros," which means "dew," and "marinus," which means "of the sea," are combined to form its scientific name, "Rosmarinus," which may be a reference to the fact that it may grow in coastal areas [1].

Historical Significance: Ancient Egypt: Rosemary was valued by the ancient Egyptians for its aromatic properties and was used in various rituals, cosmetics, and for preserving mummies [2]. Rosemary was frequently used at weddings in mediaeval Europe and served as a representation of love and faithfulness. In addition, it was utilised in fragrant flowers to cleanse the air and fight off bad spirits. It is a traditional way of Rosemary has long been a mainstay in systems of conventional herbal therapy. It was used to treat a number of

illnesses, such as respiratory problems, headaches, and stomach problems. It also have Culinary Use Rosemary is a well-known culinary herb because to its flavourful and fragrant leaves [3]. It is a vital component of Mediterranean cooking and gives roasted meats, stews, and bread a particular savoury flavor [4].

Botanical Description: An evergreen woody plant in the Lamiaceae family, typically referred to as the mint family, is rosemary (*Rosmarinus officinalis*) [5,6]. Although it originated in the Mediterranean, it is currently grown all over the world. Rosemary normally has a bushy, erect, and densely branching growth habit and may reach heights of 1 to 2 metres 3 to 6 feet [7]. The leaves are 2-4 cm long, slender, linear, and highly aromatic, with a lighter Gray-green tint on the underside and a dark green shade on the top side. At the tops of the branches of rosemary, tiny tubular blooms that are often blue, purple, or white are arranged in thick spikes. The plant's stems have bark coverings and are often fibrous and woody, having a distinctive scent when crushed.



Fig. 1. Pictorial representation of *Rosmarinus officinalis*

2. PHYTOCHEMISTRY

Rosemary is well known for having a complex and varied phytochemical makeup, which helps to explain its range of pharmacological activities. Rosemary contains a number of important compounds, including.

1. Rosmarinus Acid: Rosemary has a lot of this polyphenolic substance, which is well-known for having anti-inflammatory and antioxidant qualities.
2. Phenolic Acids: The Other phenolic acids found in rosemary, such caffeic acid and chlorogenic acid, have antioxidant and anti-inflammatory properties in addition to Rosmarinus acid.
3. Essential Oils: A number of volatile substances, including cineole, camphor, and alpha-pinene, are present in the essential oil of rosemary, which is extracted from the leaves. These substances give rosemary its distinctive scent and support its antibacterial activities [8].

4. Diterpenes: The phytochemicals in rosemary with potent antioxidant effects include the diterpenes carnosol and carnosic acid. They are thought to support its anticancer and neuroprotective properties [9].
5. Triterpenes: The triterpene ursolic acid, which is present in rosemary, has demonstrated promise for having anti-inflammatory and anticancer effects.
6. Terpenoids: Rosemary has a number of terpenoids, including beta-caryophyllene, which support its analgesic and anti-inflammatory properties [10].
7. Flavonoids: Flavonoids like luteolin (60%) and apigenin (40%), which have anti-inflammatory and antioxidant properties, are found in rosemary [11].
8. Kaempferol: Another flavonoid found in rosemary called kaempferol has been linked to anti-inflammatory, antioxidant, and anticancer properties as well as possible heart health advantages [12].
9. Luteolin: The flavonoid luteolin, which is present in rosemary and has anti-inflammatory and antioxidant effects, may improve brain function, and lower the risk of chronic disorders.
10. Apigenin: Because of its anti-inflammatory and antioxidant qualities, the flavonoid apigenin, which is found in rosemary, may improve immune function, and lower the risk of several malignancies.
11. 1,8-Eucalyptol: The rosemary terpene eucalyptol, also known as 1,8-cineole, is popular in cough medicines and ointments due to its anti-inflammatory and respiratory properties [13].
12. Alpha-Pinene: The pine-like aroma of rosemary is a result of the monoterpene pinene, which also has anti-inflammatory and bronchodilator properties [14].
13. Beta-pinene: The anti-inflammatory qualities of rosemary's second monoterpene, -pinene, also add to the herb's distinctive scent [15].
14. Limonene: A terpene present in rosemary called limonene is used in aromatherapy and has been shown to have promise for lowering anxiety and stress levels [16].
15. Myrcene: The terpene myrcene, which is present in rosemary, may have anti-inflammatory and analgesic properties [17].
16. Thymol : Thymol, a phenolic substance found in rosemary and frequently used as a food preservative due to its antibacterial and antioxidant effects [18].
17. Oleanolic acid: Oleanolic acid, which is present in rosemary, has demonstrated promise for preserving the liver and providing a number of health advantages [19].
18. Betulinic acid: Betulinic acid is a triterpenoid in rosemary with potential anticancer properties and anti-inflammatory effects [20].
19. Genkawanin: In rosemary, there is a flavonoid called genkwanin that has anti-inflammatory and antioxidant activities [21].
20. Chlorogenic acid: A polyphenol found in rosemary called chlorogenic acid has antioxidant qualities and may be able to control blood sugar levels as well as promote cardiovascular health [22].
21. Camphene: Camphene, another essential substance, has anti-inflammatory and antioxidant effects. The vast variety of pharmacological actions of rosemary, including its antioxidant, anti-inflammatory, antibacterial, and neuroprotective properties, are brought about by the synergistic action of these phytochemicals [23].
22. Carnosic acid : Carnosic acid is a potent antioxidant and anti-inflammatory compound found in rosemary, known for its neuroprotective properties and potential in combating oxidative stress [24].
23. Carnosol: Strong antioxidant and anti-inflammatory characteristics are exhibited by the rosemary compound known as carnosol, which has showed promise in cancer studies as a possible anticancer drug [25].
24. Ursolic acid: In rosemary, ursolic acid is a naturally occurring triterpenoid that has anti-inflammatory and possibly anticancer properties as well as potential benefits for muscle building and fat loss [26].
25. Caffeic acid: The antioxidant caffeic acid, found in rosemary, is renowned for its anti-inflammatory and capacity to shield cells from oxidative damage [27].
26. Quercetin: An antioxidant and anti-inflammatory flavonoid called quercetin, which is present in rosemary, may enhance cardiovascular health and lessen allergy symptoms [28].

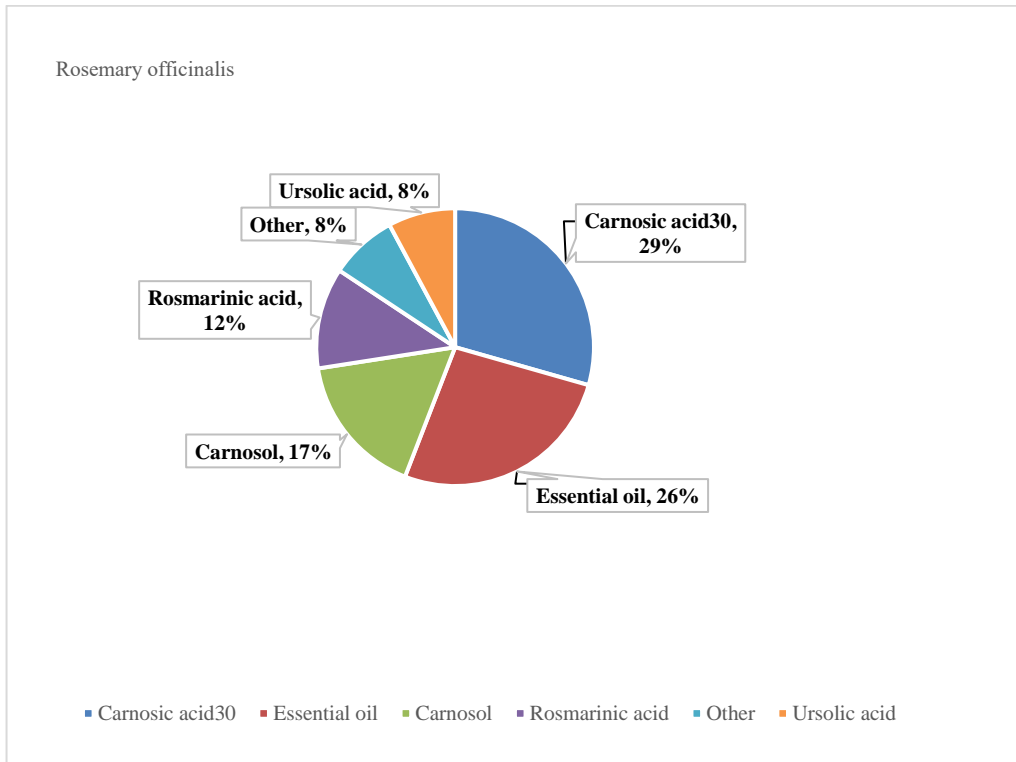


Fig. 2. Chemical substances of Rosemary officinalis

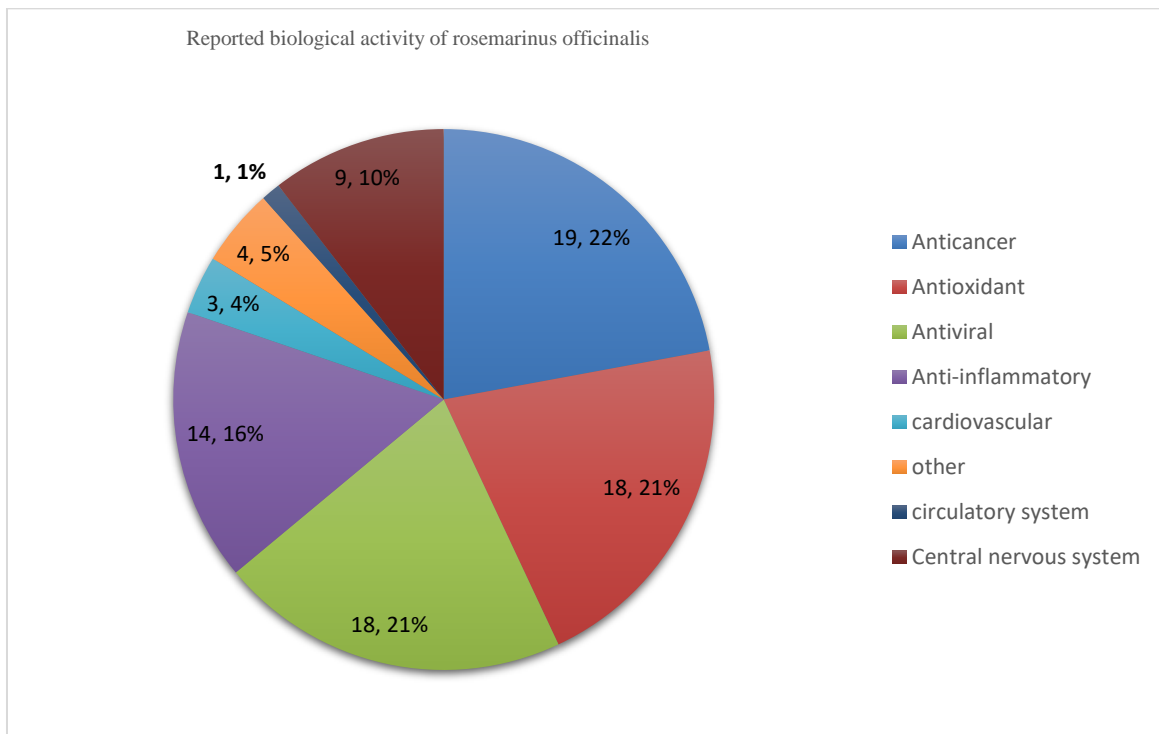


Fig. 3. Biological activity of rosemary officinalis

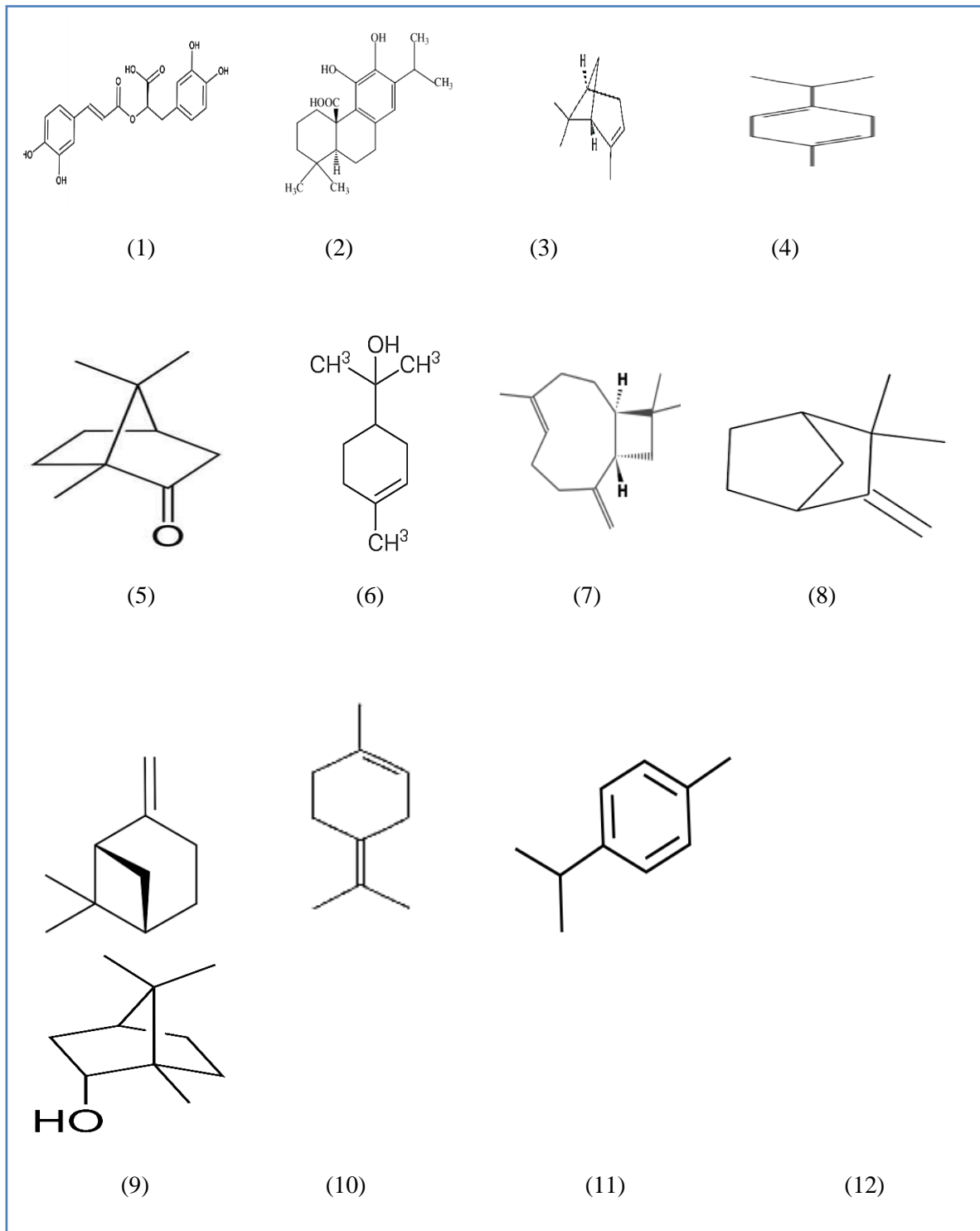


Fig. 4. Chemical figures

(1) Rosmarinic Acid, (2) Carnosic Acid, (3) Alpha-pinene, (4) Gamma-terpinene, (5) Camphor, (6) Alpha-terpinol, (7) Caryophyllene, (8) Camphene, (9) Beta-pinene, (10) Terpinolene, (11) p-cimeno, (12) Borneol, (13) Beta-Myrcene, (14) Cineole, (15) Borneyl-Acetate

Table 1. Chemical composition of Rosemary officinalis

S.no	Chemical substances	Compound	Composition
1	Terpenes	Alpha-pinene	21.3
		Gamma-terpinene	0.3
		Camphor	27.5
		Alpha- terpinol	0.7
		Caryophyllene	1.1
2	Essential oil	Camphene	8.7
		Beta-pinene	4.7
		Terpinolene	0.3
		p-cimeno	1.4
3	Bicyclic monoterpene	Borneol	2.5
4	Mono terpenoids	Beta -Myrcene	1.3
		Cineole	28.5
5	Ester	Bornyl-Acetate	1.3

3. PHARMACOLOGICAL ACTIVITIES

- 1. Anti-oxidant Properties:** In his review studied By Using various solvents, The anti-oxidative activity has been assessed. In this regard, Rosmanol demonstrated an anti-oxidant capacity that was four times more than BRT and BRA (synthetic antioxidants) in both linoleic acid and lard, according to Inatani et al., The anti-oxidant activity of carnosol and rosmanol was also reported in this work using the ferric thiocyanate and TBA techniques. They discussed the relationship between anti-oxidant activity and chemical structure. Aruoma et al. investigated the rosemary's anti- and pro-oxidant qualities. Carnosic acid and carnosol, which account for 90% of the characteristics, are the primary compounds having anti-oxidant effects. Both act as lipid peroxidation inhibitors in liposomal and microsomal systems, excellent CCl₃O₂ (peroxyl radical) scavengers, and reducers of cytochrome c and the removal of hydroxyl radicals. Carnosic acid specifically scavenges H₂O₂, but it also has the potential to serve as a substrate for the peroxidase system [29].
- 2. Anti-Inflammatory Properties:** In his review study Rosemarie Acid may be a good choice for the therapy of asthma since it inhibits the nuclear factor-B (NF-B) pathway, which is the primary cause of allergic asthma. The additional components of Carnosol Acid and Uroslic Acid lower interleukin (IL)-4, IL-5, and IL-13 expression while reducing airway inflammation. Conditions like arthritis and other inflammatory illnesses may benefit

from its anti-inflammatory effect. The decreased the inflammatory mediators' synthesis in a dose-dependent way. Maximum NO, PGE₂, and TNF- production suppression by -bisabol in RAW cells was 55.5%, 62.3%, and 45.3%, respectively. Similar to an equivalent dose of the well-known anti-inflammatory drug, -bisabol (50.0 g/mL), -bisabol generated a degree of inhibition [30].

- 3. Anti-microbial Properties:** In his review the ability of an extract of *Rosmarinus officinalis* to kill bacteria in in situ early oral biofilms. There were considerably fewer colony-forming units in the *R. officinalis*-treated biofilms than in the untreated controls (p 0.001). For aerobic and anaerobic bacteria, the decrease range of log₁₀ was 1.64-2.78 and 2.41-3.23, respectively. There was significant intra- and interindividual variation in the bacterial makeup. The average concentration of each bacterial taxon, with the exception of *Campylobacter* spp., was lower following treatment with *R. officinalis* than in the untreated biofilms. Only 11 bacterial species were found in the *R. officinalis*-treated biofilms, compared to a total of 49 distinct species in the untreated biofilms. The *R. officinalis*-treated biofilms had considerably fewer surviving bacteria than the untreated biofilms, according to live/dead staining [31].
- 4. Neuroprotective Properties:** In part of these review inhibiting the NLRP3 inflammasome, this study focuses on the potential uses of CA and CS for the treatment of Alzheimer's disease (AD), Parkinson's disease (PD), and coronavirus disease (COVID-19). data suggesting that

CA or rosemary extracts containing CA may operate as a potent preventative treatment against both acute and chronic pathological events brought on by SARS-CoV-2 infection as well as other long-term neurodegenerative illnesses including AD and PD [32]. Diterpenes found in rosemary, such as carnosic acid and carnosol, have neuroprotective properties. These substances might aid in preventing the deterioration and destruction of brain cells, hence lowering the chance of neurodegenerative illnesses like Alzheimer's and Parkinson's. Additionally, rosemary may improve memory recall and cognitive performance [33].

5. **Potential Anticancer Properties:** In This review we can find indicate that targeting colon cancer cells by increasing intracellular ROS and decreasing cell survival mechanisms may suppose a therapeutic option in colon cancer through the combination of rosemary compounds and chemotherapeutic drugs. The four drugs' antiproliferative activities in HT-29 cells as compared to RE. The findings indicate that the antiproliferative impact is dose-dependent, that the triterpenes UA and BA have a stronger antiproliferative effect than the diterpenes CA and CAR, and that all isolated chemicals examined had lower IC50 values than RE extract. According to certain studies, rosemary extracts may be able to fight cancer. However, further research is required to fully comprehend these possible advantages. Rosemary has promise in a number of pharmacological activities, but it's vital to keep in mind that its efficacy might change based on elements like the specific chemicals contained in the plant, the method of preparation (such as an essential oil, extract, or dried herb), and the dosage utilised [34]. Before using Rosemary or any herbal medicine for a particular health issue, always talk to a doctor, especially if you have underlying medical issues or are on medication [35].
6. **Gastrointestinal Health:** In his review In vivo research has demonstrated that rosemary treatment improves GI health by reducing oxidative stress and inflammation in the GI tract [36]. Traditional remedies for digestive problems including indigestion and bloating include rosemary. It could aid in gastrointestinal muscle relaxation and lessen irritable bowel syndrome (IBS) symptoms. According to his review, the aetiology of IBS is unknown, although over 60% of patients have serious psychological issues [37].
7. **Skin Health:** In his review Rosemary is a valuable ingredient in skincare products because of its anti-inflammatory and antioxidant effects. It could lessen skin inflammation, ease itchiness, and defend against UV-induced skin ageing [38].
8. **Cardiovascular Health:** In his review study the Rosmarinic acid and flavonoids, two substances found in rosemary, it has been proven to promote vasodilation. which is the expansion of blood vessels, makes it simpler for blood to flow through them and can lower blood pressure. Rosemary extract may reduce both systolic and diastolic blood pressure by relaxing the blood vessels [39]. Rosemary may benefit cardiovascular health by enhancing lipid profiles and lowering blood pressure, according to some study. It could lower the chance of developing heart disease [40].
9. **Sperm Motility:** In his review studied The Rosemary officinalis affects sperm motility directly. Herbs like rosemary are not frequently linked to this particular function since sperm motility is a complicated biological process that is regulated by a number of variables [41].
10. **Anti-Diabetic Activity:** In his review Studies on metabolomics were conducted on the impact of herbal remedies on diabetes and obesity, identifying possible biomarkers and describing the metabolic changes connected to the onset of diabetes. The results demonstrated that lipid metabolism (acetoacetate, acetate), glycolysis/gluconeogenesis (glucose, pyruvate, lactate), TCA cycle (succinate, citrate, -hydroxybutyrate, 2-oxoglutarate), and amino acid metabolic pathways (valine, leucine, and isoleucine, hippurate, creatine) are all involved in metabolism [42]. The chemicals in rosemary, such as rosmarinic acid, may help with glucose metabolism and insulin sensitivity. The data is still lacking in comparison to other plants like cinnamon or bitter melon, though [43].
11. **Anti-Depressant Activity:** In his review studied Rosemary has long been valued for its fragrant qualities, and some people may find that breathing its perfume improves their mood [44]. It isn't often regarded as the main herbal treatment for

depression, though [45]. For example, St. John's Wort is a plant for depression that has received considerable research [46].

12. Anti-Obesity Activity: In his review part There isn't much proof to support the idea that rosemary aids with weight management. Although some research has suggested that specific chemicals in rosemary may aid in fat metabolism, this field of study is still in its infancy, and the results, if any, are not yet clear [47]. Although Rosemary has a long history of usage in both cooking and medicine, additional study is necessary to completely comprehend its pharmacological characteristics and their unique methods of action in both fields. It is crucial to get the advice of a trained healthcare expert before taking Rosemary or any other herbal medicine for particular health issues including diabetes, depression, or obesity [48]. The herb rosemary may lower hunger and calorie consumption. Some rosemary constituents, including rosmarinic acid, have been proposed to affect hormones that control appetite, perhaps preventing overeating [49].

13. Antiviral Activity: In his review he studied an HSV-1 antiviral test was used to assess the rosemary extract, and the degree of viral replication in Vero cells was measured using a cytopathic effect assay. According to the current investigation, rosemary extract at a concentration of 30 g/ml inhibited HSV-1 plaques by 55% while inhibiting HSV-2 plaques at a value of 40 g/ml. At 50 g/ml, the extracts totally prevented the development of HSV-1 and HSV-2 plaques. Superoxide anion radical scavenging activity was detected at 65.74 mg/ml, whereas DPPH radical scavenging activity was recorded at 67.34 mg/ml [50]. The possible antiviral activities of rosemary extracts and essential oils. Certain viruses may be resistant to the antiviral effects of rosemary components including Rosmarinus acid and essential oils, according to some study [51]. It's important to remember that rosemary's antiviral properties are less well-known than those of other herbs and substances [52]. More study is required to fully understand the range of antiviral activity and its therapeutic implications because the majority of investigations have been carried out in vitro (in the lab) [53].

14. Antifungal (Anti-Mycotic) Activity: In his review studies A panel of fungal species, including common diseases like *Candida albicans*, *Aspergillus fumigatus*, and *Trichophyton rubrum*, were successfully eradicated by rosemary officinalis extracts. It was shown that the antifungal effects were dose-dependent, with greater inhibition seen at higher extract concentrations [54]. The carnosic acid, rosmarinic acid, and several terpenoids, were found in the Rosemary extracts after being subjected to gas chromatography-mass spectrometry (GC-MS) analysis. These substances are well-known for having which may help explain why antifungal effects have been seen [55]. Rosemary extracts and essential oils have demonstrated antifungal properties in various studies. These antifungal effects have been observed against a range of fungi, including *Candida* species [56]. The antifungal activity of rosemary is often attributed to its volatile compounds, such as cineole, camphor, and borneol [57]. These compounds have been shown to inhibit the growth of fungi and may have potential applications in the treatment of fungal infections [58].

15. Hepatotoxicity: In his review studies Hepatotoxicity is a medical term for liver toxicity or injury. Although rosemary is often used in small amounts in food preparation, there have been a few cases of hepatotoxicity linked to excessive or extended use of large dosages of supplements or essential oils containing rosemary [59]. If you have liver issues or are worried about rosemary's potential for liver damage, it's crucial to use it sparingly and speak with a medical practitioner, especially if you plan to utilise concentrated versions like essential oils.

4. POTENTIAL THERAPEUTIC APPLICATIONS OF ROSEMARY OFFICINALIS IN VARIOUS MEDICAL CONDITIONS

1. Cognitive Function: The ability of rosemary to enhance memory and cognitive function has been researched. According to certain research, the scent of rosemary essential oil may improve cognitive function and alertness. Because

of its possible advantages for cognition, it is frequently utilised in aromatherapy.

2. **Arthritis and Inflammation:** Rosmarinic acid and carnosol, two substances found in rosemary, have anti-inflammatory actions. These substances might be helpful in treating inflammatory diseases like osteoarthritis.
3. **Diabetes:** According to certain studies, Rosemary may reduce the risk of diabetes by enhancing insulin sensitivity and glucose metabolism. It might be viewed as an additional method of managing diabetes.
4. **Antimicrobial and Antifungal:** It has been shown that rosemary essential oil contains antibacterial and antifungal effects. It may be used to natural cleaning solutions or applied topically to treat small skin problems.
5. **Neuroprotection:** In preclinical investigations, Rosemary constituents including rosmarinic acid and carnosic acid shown neuroprotective properties. These substances might help treat disorders linked to neurodegeneration by shielding neurons from oxidative damage and inflammation.
6. **Stress and Anxiety:** According to certain research, rosemary aromatherapy may have a relaxing impact and lower levels of tension and anxiety. It can be included into relaxing methods or diffused.
7. **Pain Management:** Rosemary can be used topically as creams or oils for pain relief because of its anti-inflammatory effects, particularly in disorders requiring muscular or joint discomfort.
8. **Cancer Prevention:** Although further study is required, several studies have suggested that rosemary extracts may be useful in preventing cancer. In preclinical research, substances like carnosol and carnosic acid shown anticancer effects.
9. **Respiratory Health:** During respiratory infections, rosemary inhalation or steam inhalation with rosemary essential oil may facilitate better breathing and reduce respiratory congestion.

5. SAFETY CONCERNS, POTENTIAL SIDE EFFECTS, AND TOXICITY ISSUES

1. **Allergic Reactions:** Rosemary may cause allergic reactions in certain people. Skin rashes, itching, and in extreme cases,

respiratory symptoms including shortness of breath, are all examples of allergic responses. If you believe you may be allergic to rosemary, stop using it and, if necessary, get medical help.

2. **Gastrointestinal Upset:** Rarely, consuming too much rosemary or rosemary oil may cause gastrointestinal distress, including nausea, vomiting, and stomach discomfort.
3. **Blood Clotting:** Rosemary could have a little blood-thinning effect. While most people are usually unaffected by this, those who are on blood-thinning drugs (anticoagulants) should use caution and speak with a doctor before taking significant doses of rosemary supplements or extracts.
4. **Hepatotoxicity:** Rare instances of liver damage linked to the use of large dosages of rosemary supplements or essential oil have been made. Vomiting, nausea, and discomfort in the abdomen are possible symptoms. Rosemary should be used with caution and in consultation with a healthcare provider by those who have liver issues or are taking drugs that may harm the liver.
5. **Pregnancy and Breastfeeding:** Rosemary should only be used as a flavouring agent in small doses if a woman is pregnant or nursing; concentrated versions like essential oils or supplements should be avoided.
6. **Essential Oil Safety:** Because it is so concentrated, rosemary essential oil should be handled with care. A carrier oil should be used to dilute it before topical administration. It is best to avoid ingesting essential oils unless specifically instructed to do so by a licenced aromatherapist or healthcare professional.
7. **Quality and Purity:** To assure purity and reduce the possibility of impurities, it is crucial to select premium goods from reliable suppliers when taking Rosemary supplements or essential oils.

6. CONCLUSION

Due to its phytoconstituents, Rosmarinus officinalis is today recognised as a mystical, traditional medicinal plant. It also includes phenolic acid, flavonoids, triterpenoids, and diterpenoids, which are frequently found in seasonings for foods like lamb, duck, chicken, sausages, stews, and potatoes. Additionally, the

herb Rosmarinus includes substances that have antioxidant, antimicrobial, anti-viral, anti-mycotic, hepatotoxic, anticancer, smooth muscle, sperm motility, peptic ulcer, anti-proliferative, anti-diabetic, anti-depressant, anti-obesity, and neuroprotective potential.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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