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Review Article

Exploring the potential of rose oil

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ABSTRACT

Growing consumer awareness has highlighted the importance of natural and renewable resources for health, wellness, and environmental sustainability. Rose oil, derived from the petals of various species of roses, is rich in bioactive compounds such as geraniol, citronellol, nerol and phenolic acids. It contains antioxidants, vitamins, and natural lipids, making it highly valued for its therapeutic, cosmetic, and medicinal properties. Known for its antimicrobial, anti-inflammatory, and anti-aging effects, rose oil is beneficial in promoting skin health, reducing stress, and improving mood. Additionally, it is widely used in aromatherapy for its calming effects, enhancing mental clarity, and alleviating anxiety. Rose oil exhibits significant antibacterial, antifungal, and antioxidant activities, making it a natural choice for applications in the food, pharmaceutical, and cosmetic industries. The oil is also rich in phytochemicals that have shown potential anti-cancer and anti-diabetic effects. Its anti-inflammatory properties make it useful for topical applications in treating skin conditions like eczema and acne. The production of rose oil involves sophisticated extraction methods such as steam distillation and solvent extraction to retain its bioactive compounds. This work reviews the in-vitro and invivo analysis of rose oil for various therapeutic applications and highlights its potential as a natural preservative and antimicrobial agent. Rose oil's versatile applications, from perfumery to medicinal uses, underscore its significance as a renewable and sustainable resource. Beyond its direct health benefits, rose oil plays an integral role in holistic well-being. Its psychoactive properties have been shown to influence the nervous system, helping to regulate cortisol levels and reduce stress-induced inflammation. Research indicates that regular use of rose oil in aromatherapy can enhance emotional balance, making it a powerful tool for managing anxiety, depression, and sleep disorders. Moreover, the oil's anti-spasmodic properties make it effective in alleviating menstrual pain and muscle cramps. As global interest grows in plantbased and sustainable solutions, rose oil continues to garner attention for its potential in revolutionizing the wellness and healthcare industries.

Keywords: Mirror neuron system, Action observation therapy, Cerebral palsy, Pediatric neurorehabilitation, fMRI, Upper extremity, Neuroplasticity.

INTRODUCTION

The global demand for natural and renewable resources has led to the exploration of essential oils, among which rose oil holds a prominent place. Rose oil, also known as attar of roses, is derived primarily from the petals of various species of roses such as *Rosa damascena* and *Rosa centifolia*. Globally, the production of rose oil is concentrated in countries like Bulgaria, Turkey, and Iran, with Bulgaria alone producing over 1.5 tons annually, meeting about 70% of the world's demand [1]. The oil is highly valued in the cosmetic, pharmaceutical, and food industries, owing to its rich composition of bioactive compounds like geraniol, citronellol, nerol, and phenolic acids. The production of rose

oil involves a labor-intensive process, as approximately 4,000 kilograms of rose petals are required to produce just 1 kilogram of oil [2].

This oil has demonstrated potent antioxidant, antimicrobial, and anti-inflammatory properties. The presence of compounds that scavenge free radicals, such as polyphenols and terpenes, contributes to its effectiveness in reducing oxidative stress and combating pathogens [3]. Furthermore, rose oil has shown remarkable benefits in skin health, particularly in treating eczema, acne, and age-related skin damage, making it a staple ingredient in premium skincare products [4].

Despite its high value, the rose oil industry faces challenges related to production residues. Large quantities of rose petals and biomass are left as waste after extraction, posing environmental concerns. This waste material, however, contains residual bioactive compounds that can be utilized for various applications, such as animal feed, bioenergy, or natural fertilizers, emphasizing the need for sustainable practices in the rose oil industry. Transforming rose oil waste into value-added products not only enhances the overall economics of production facilities but also significantly reduces environmental impact. Rose oil's versatility as a therapeutic agent, combined with its potential for sustainable and ecofriendly production, underscores its importance in modern industries. Ongoing research into its bioactive properties and efficient extraction methods promises to expand its applications in wellness, medicine, and environmental sustainability.

Synonyms

Rose essential oil, Attar of roses, Rose otto, Rose petal oil, Rose flower oil, Rosa damascena oil, and Rose absolute.

Biological Source

Rose oil is derived from the petals of various species of roses, primarily *Rosa damascena*, *Rosa centifolia*, and other cultivated rose varieties. The oil is extracted through methods like steam distillation or solvent extraction from fresh rose petals.

Botanical classification

Kingdom: Plantae

Clade: Angiosperms

Order: Rosales

Family: Rosaceae

Genus: Rosa

Species

Rosa damascena (Damask rose), *Rosa centifolia* (Cabbage rose), among others.

History and origin

Rose oil has a long history, dating back to ancient civilizations in the Middle East and Mediterranean regions. The first known extraction of rose oil is believed to have occurred around the 10th century in Persia (modern- day Iran). The *Rosa damascena* variety, originating in the Middle East, is one of the most famous sources of rose oil. Over time, the cultivation of roses spread to Europe, India, and other parts of the world. Rose oil became highly regarded for its fragrance, therapeutic properties, and use in religious rituals, perfumes, and cosmetics.

The demand for rose oil in the perfume industry grew significantly during the 16th and 17th centuries, particularly in France. Rose oil was also used in traditional medicine for a variety of ailments, including skin conditions, stress, and digestive problems. In modern times, rose oil continues to be highly valued in the perfume and cosmetic industries for its therapeutic and fragrant properties.

Chemical composition

Rose oil contains a complex mixture of volatile compounds, including terpenes, phenolic compounds, alcohols, aldehydes, and esters. The key constituents of rose oil include geraniol, citronellol, nerol, phenylethanol, and rosmarinic acid, which contribute to its antioxidant, antiinflammatory, antimicrobial, and antidepressant effects. The chemical composition of rose oil can vary slightly depending on the rose species, cultivation conditions, and extraction methods. Typically, geraniol and citronellol are the dominant components, accounting for 30–50% of the oil.

Chemical structure of rose oil

Rose oil's chemical composition is primarily a complex mixture of alcohols like citronellol, nerol, and geraniol, along with hydrocarbons such as nonadecane and heneicosane. Other significant compounds include phenethyl alcohol, farnesol, and rose oxide. The exact percentages vary depending on the species and growing conditions, but these listed components consistently appear as major constituents.

Major component

Citronellol: A primary alcohol that contributes significantly to the scent and quality of rose oil. Geraniol: Another key alcohol, it is a major constituent that influences the oil's fragrance.

Nerol

Often found alongside geraniol, nerol is an isomer that is also a significant part of the oil's composition.

Phenethyl alcohol: A major component, particularly in rose water and absolute, responsible for a significant part of the floral scent.

Hydrocarbons: Aliphatic hydrocarbons like nonadecane and heneicosane (C19 and C21) are present, contributing to the oil's overall profile.

Minor component

Farnesol: A sesquiterpene alcohol present in smaller amounts.

Rose oxide

A cyclic ether that is an important trace component, contributing a characteristic fresh rose scent.

Linalool: An alcohol with a floral, woody aroma.

Eugenol: A phenolic compound found in smaller quantities.

Equipment for formulation / extraction of rose oil

Raw material processing

Weighing balance – for accurate measurement of rose petals.

Scissors / knives – for trimming and preparation of petals.

Sieve / mesh – for cleaning and removing impurities.

Extraction equipment

Depending on the method used:

Steam distillation (Most common method)

Clevenger apparatus or steam distillation unit – for extracting essential oil by steam distillation. Round-bottom flask / distillation flask – for heating the water and plant material.

Heating mantle / water bath – to provide uniform heating.

Condenser – for condensing the vapors.

Storage

Amber-colored glass bottles – for storing rose oil (to protect from light). Refrigerator – for storage at low temperatures to prevent degradation [5].

Equipment for evaluation / analysis of rose oil

Physical evaluation

pH meter – to determine pH (if formulated as an oil preparation). Refractometer – to measure refractive index.

Pycnometer / specific gravity bottle – to determine specific gravity. Viscometer – to measure viscosity.

Melting point apparatus – if concretes or absolutes are studied. Color comparator – for color evaluation.

Odor evaluation setup (panel of trained evaluators) – for sensory testing.

Chemical evaluation

Gas Chromatography (GC) / GC–MS – for identification and quantification of volatile components.

Infrared (IR) spectrophotometer – to identify functional groups and confirm purity.

UV–Visible spectrophotometer – for absorbance studies (if applicable). Titration setup (acid value, ester value) – for chemical characterization.

Pharmacological activities of rose oil

Rose oil has several pharmacological activities that contribute to its therapeutic benefits:

Antioxidant

The high levels of phenolic compounds in rose oil help neutralize free radicals, reducing oxidative stress and preventing cellular damage.

Antimicrobial

Rose oil has demonstrated antibacterial and antifungal properties, making it effective against a range of pathogens.

Anti-inflammatory

Rose oil has been shown to reduce inflammation, making it useful in treating conditions like eczema, acne, and other skin inflammations.

Antidepressant and anxiolytic

In aromatherapy, rose oil is known for its **mood-enhancing** effects, promoting relaxation, reducing anxiety, and improving overall mental well-being.

Anticancer

Some studies suggest that compounds in rose oil, such as rosmarinic acid, may exhibit potential anticancer effects, particularly against breast cancer.

Cardioprotective

Rose oil may help in improving heart health by reducing stress and lowering blood pressure due to its calming effects

Antidepressant and anxiolytic activity

Mechanism

Rose oil modulates the serotonergic and dopaminergic systems and influences GABAergic neurotransmission [6].

Evidence

Inhalation or topical application reduces symptoms of anxiety and depression in both animal models and humans. Clinical use: Aromatherapy with rose oil can reduce anxiety in laboring women, postoperative patients, and individuals with depression.

Sedative and hypnotic effects

Mechanism

Likely due to central nervous system (CNS) depressant activity through GABAergic modulation. **Evidence**: Inhalation produces relaxation and decreases

sympathetic nervous system activity (lower heart rate and blood pressure) [7].

Analgesic and antinociceptive effects
Mechanism

Inhibition of peripheral and central pain pathways, possibly through opioid and serotonergic systems.

Evidence

Rose oil (inhalation or topical) decreases pain intensity in animal models and in patients with dysmenorrhea and postoperative pain.

Anti-inflammatory and antioxidant effects
Mechanism

Inhibition of pro-inflammatory mediators (TNF-α, IL-6, COX-2) and enhancement of antioxidant enzyme activity.

Evidence

Rose oil and extracts reduce edema, oxidative stress markers, and lipid peroxidation in various inflammation models.

Antimicrobial and antiviral activity
Mechanism

The phenolic components (citronellol, geraniol) disrupt bacterial cell membranes and interfere with microbial metabolism.

Active against

Staphylococcus aureus, Escherichia coli, Candida albicans, and some viruses.

Applications

Topical antiseptic, cosmetic preservative, and potential use in natural antimicrobial formulations.

Antispasmodic and smooth muscle relaxant effects
Mechanism

Calcium channel blockade and nitric oxide-mediated relaxation.

Evidence

Reduces uterine contractions and gastrointestinal spasms in animal studies [8].

Aphrodisiac and hormonal modulating effects
Mechanism

Increases dopamine and testosterone levels, possibly through limbic system stimulation.

Evidence

Some studies report improved sexual function and libido in male rats and humans.

Neuroprotective effects
Mechanism

Antioxidant and anti-inflammatory protection against neurotoxicity and oxidative damage.

Evidence

Protective effects seen in Alzheimer's and ischemic brain models.

Dermatological and cosmetic benefits
Mechanism

Promotes wound healing, hydration, and antimicrobial protection.

Applications

Common in skincare for its soothing, anti-aging, and anti-acne properties.

Anticancer activity (experimental)
Mechanism

Induction of apoptosis and inhibition of proliferation in cancer cell lines.

Evidence

Limited in vitro studies show cytotoxic activity against breast and cervical cancer cells.

Health benefits of rose oil

Rose oil offers several health benefits, including:

Rose oil as an anti-inflammatory and antioxidant

It helps reduce inflammation and fights oxidative stress in the body, benefiting the skin and overall health.

Rose oil for skin care

Rose oil is widely used in cosmetics for its skin-healing properties, including its ability to treat scars, acne, and wrinkles [9].

Rose oil for emotional health

The aroma of rose oil has been found to alleviate stress, depression, and anxiety, promoting emotional well-being.

Rose oil for cardiovascular health

The anti-inflammatory and stress-reducing properties of rose oil may help support heart health.

Rose oil for digestive health

Rose oil is believed to improve digestion and help with issues like indigestion and bloating.

Skin and hair benefits
Hydrates and nourishes

It restores and maintains skin's moisture balance, making it soft and radiant, especially for those with dry skin.

Anti-aging

Its antioxidants help protect skin from free radicals, increase collagen production, and reduce the appearance of wrinkles and fine lines [10].

Soothes inflammation

It can reduce redness, irritation, and symptoms of conditions like eczema and rosacea.

Promotes skin regeneration

It aids in skin renewal, healing, and can minimize the appearance of scars [11].

Strengthens hair

It moisturizes, strengthens, and adds shine to hair while also nourishing the scalp to help with issues like dandruff.

Side effects of rose oil

While rose oil has numerous health benefits, it can cause some side effects if not used properly:

Skin irritation

Direct application of rose oil may cause irritation or allergic reactions in individuals with sensitive skin. It is important to conduct a patch test before use.

Photosensitivity

Rose oil can make the skin more sensitive to sunlight, increasing the risk of sunburn [12].

Dilution required

Rose oil should always be diluted with a carrier oil (e.g., jojoba or coconut oil) before topical use to avoid irritation and skin sensitivity.

Use during pregnancy

Pregnant women should consult a healthcare provider before using rose oil, especially in large quantities, due to its potential effect on hormonal balance. By understanding its composition, benefits, and proper usage, rose oil can be a valuable addition to therapeutic, cosmetic, and wellness practices [13].

RESULTS & DISCUSSION

The results of this review highlight that rose oil, derived from Rosa damascena and Rosa centifolia, possesses significant therapeutic, cosmetic, and pharmacological potential owing to its rich composition of bioactive compounds such as geraniol, citronellol, nerol, phenylethanol, and phenolic acids. Analytical evaluations using techniques like GC–MS and IR spectroscopy confirm the presence of these key constituents responsible for its antioxidant, antimicrobial, and anti-inflammatory activities. Pharmacological findings demonstrate that rose oil exhibits broad-spectrum biological effects, including antidepressant, anxiolytic, analgesic, antispasmodic, and neuroprotective actions, primarily mediated through modulation of neurotransmitter systems and inhibition of inflammatory mediators. Experimental studies further support its efficacy in skincare, where it promotes hydration, collagen synthesis, and wound healing while reducing oxidative stress and microbial infections. In vitro analyses show that compounds like rosmarinic acid and geraniol may exert anticancer and cardioprotective effects, enhancing its value in therapeutic formulations. Despite its vast potential, the review identifies challenges in large-scale production, such as the high cost of raw materials and waste generation, which could be mitigated through sustainable extraction and valorization of by-products. Overall, the discussion underscores rose oil's multifaceted pharmacological activities and industrial applications, supporting its growing importance as a natural, renewable bioactive ingredient for pharmaceutical, cosmetic, and aromatherapy purposes [14].

CONCLUSION

In conclusion, rose oil represents a remarkable natural product with diverse therapeutic, cosmetic, and pharmacological benefits, attributed to its rich composition of bioactive compounds such as geraniol, citronellol, nerol, phenylethanol, and rosmarinic acid. Extensive studies have demonstrated its potent antioxidant, anti-inflammatory, antimicrobial, antidepressant, and neuroprotective activities, validating its traditional and modern medicinal applications. The oil's ability to promote skin health, relieve anxiety, reduce pain, and potentially inhibit cancer cell growth highlights its broad therapeutic potential. Furthermore, its applications extend beyond healthcare into perfumery, aromatherapy, and the cosmetic industry, emphasizing its commercial and societal importance. However, the production of rose oil remains challenged by its labor-intensive extraction process and environmental concerns associated with post-distillation waste. Thus, future research should focus on sustainable extraction methods, efficient utilization of rose biomass, and advanced formulation technologies to enhance its yield, stability, and efficacy. Overall, rose oil stands as a promising, eco-friendly, and multifunctional bioactive agent with immense potential for integration into pharmaceutical and wellness industries, contributing to both human health and environmental sustainability.

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