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Role of medicinal and aromatic plants in modern cosmeceuticals

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Abstract

This review article explores the significant role of medicinal and aromatic plants (MAPs) in modern cosmeceuticals, a category of skincare products that merge the benefits of cosmetics and pharmaceuticals. The origins of cosmeceuticals trace back to traditional plant-based preparations for skin health and beauty enhancement, which have evolved into advanced formulations combining nature's efficacy with scientific innovation. While not officially categorized by regulatory bodies, cosmeceuticals are recognized for their ability to improve skin texture, pigmentation, hydration, and elasticity while addressing minor skin disorders. The versatility of MAPs in cosmeceuticals stems from their rich composition of bioactive compounds such as antioxidants, essential oils, flavonoids, and vitamins, which offer moisturizing, anti-aging, skin-brightening, anti-inflammatory, and anti-acne properties. Additionally, the application of MAPs extends to hair care and aromatherapy, utilizing specific plant extracts to nourish hair, soothe the scalp, and enhance sensory appeal. Key ingredients include chamomile, *Centella asiatica*, liquorice, neem, green tea, turmeric, rosemary, and essential oils from plants like lavender and eucalyptus. This review highlights the increasing consumer preference for plant-based cosmeceuticals, alongside discussions on sustainability, traditional ethnobotanical knowledge, and advancements in extraction methods for optimizing bioactive compound efficacy. The continued exploration of MAPs provides potential pathways for developing sustainable, multifunctional cosmeceuticals, with applications that address both aesthetic and therapeutic needs in modern skincare.

Keywords: Medicinal, Aromatic, Cosmeceuticals, bioactive, skincare, moisturizers

Introduction

For thousands of years, people have used preparations to enhance skin health and appearance, which has evolved into today's cosmetics. As the primary barrier to the environment, our skin actively defends us against external aggressions. Plants have been essential in offering ingredients that can soothe and protect the skin. Modern cosmetics now not only improve hydration and reduce redness but can also enhance skin elasticity (Ahshawat *et al.*, 2008) ^[1].

Dr. Albert Kligman introduced the term "cosmeceutical" in 1984 to define a hybrid class of products that lie between cosmetics and drugs, intended to improve skin health and appearance. This category, however, is not officially recognized in either the United States or the European Union. The Federal Food, Drug, and Cosmetic Act (FD&C Act) uses the following definition for a cosmetic: "articles intended to be rubbed, poured, sprinkled, or sprayed on, introduced into, or otherwise applied to the human body or any part thereof for cleansing, beautifying, promoting attractiveness, or altering the appearance," while a drug is defined as "an article intended for use in the diagnosis, mitigation, treatment or prevention of disease or intended to affect the structure or any function of the body." In general, a cosmeceutical product is considered the product that is intended for application in near or near-normal skin, should display a benefit for a minor skin disorder, and should have a very low-risk profile. (Sotiropoulou *et al.*, 2021) ^[24] At present, there is no universally recognized classification system for cosmeceuticals, leading to diverse categorization approaches based on their intended uses or specific conditions they address. These products are generally grouped into several categories, such as skin-lightening and depigmentation agents,

sunscreens, moisturizers, anti-wrinkle and anti-aging treatments, scar reduction solutions, antioxidants, hair-strengthening products, and treatments for specific skin disorders (Pandey *et al.*, 2023) ^[22]. A variety of cosmeceuticals exist that can improve the appearance of skin by affecting skin texture, wrinkling, and pigmentation (Draeos, 2007) ^[8].

Plants have been prominent in human life for centuries, especially in health, skincare, and beauty rituals. Across various cultures, plant-based extracts and preparations have been valued for their rejuvenating and healing effects on the skin. These natural sources are rich in bioactive compounds, including antioxidants, vitamins, and essential oils, which offer potent protective, nourishing, and restorative properties. Even today, the demand and utilization of Phytocosmetics have increased in the personal care system. The inherent complexity of these plant molecules continues to attract attention, not only for their traditional uses but also as promising ingredients in modern cosmeceuticals, merging nature's wisdom with scientific innovation in skincare. Research into the value and use of plant and mineral resources in cosmetics continued over the centuries evolving into what we consider to be cosmeceuticals. Interestingly, there is a great tendency of consumers to return to the use of herbs/herbal products for various applications to implement a more natural mode of life (Mahomoodally and Ramjuttun, 2016) ^[15]. Traditionally, the use of plants against skin diseases and specifically for cosmeceutical purposes has been a common practice among many cultures. Medicinal and aromatic plants have long enchanted both consumers and industries in the realm of cosmetics and personal care. Valued for their healing qualities and pleasing fragrances, these plants have become key ingredients in products that offer both beauty and well-being. Integrating these natural elements into cosmetic and personal care items has transformed the industry while also sparking discussions on sustainability, effectiveness, and the social and economic impact on communities involved in their growth and harvest (Zhang *et al.*, 2024). A majority of the plant ingredients (oat, walnuts, chamomile, carrot, almonds, cucumber, lavender, mint, rose, and sweet violet petals) are utilized in modern Phyto cosmetics, including, shampoos, creams, lotions, and sun care products.

Application of MAPs in the Cosmetic Industry

The science of cosmetology is an ancient science. The very first use of cosmetics dates to approximately 2500 and 1550 B.C. during the Indus Valley civilization (Lal, 2002) ^[14]. Ethnobotanical knowledge along with Ayurvedic references have been used as sources for overall healthcare. Nevertheless, with advances in technology, researchers have led to newer and improved formulations. Formulators are striving to prepare highly differentiated multifunctional products that also have the essence of aesthetics having active ingredients. The ubiquitous curiosity in medical treatment and beauty routines has now led to the requisition for certain fruitful botanical extracts (Alcalde, 2008) ^[2]. The evaluation of plants' chemical composition and biological effects is essential to identify their beneficial properties. Among the various natural compounds, those with antioxidant effects are particularly important for their application in the cosmeceutical sector. However, due to the increasing interest in these products, it is crucial to assess the extinction risks to promote sustainable use and the

implementation of effective extraction methods (Hazrati *et al.*, 2024) ^[9]. Medicinal and aromatic plants hold immense potential in the cosmetic industry, with hundreds of compounds isolated and identified from these plants. Recently, they have been widely explored for use as moisturizers, anti-aging treatments, sunscreens, skin brighteners, hair care products, and in aromatherapy, as well as for addressing issues like dry skin and acne (Vartak *et al.*, 2022) ^[27].

Moisturizing properties

Moisturizers are among the most used products in cosmetics, widely recognized for their ability to soften the skin. They are particularly effective in alleviating dry skin, which can lead to discomfort such as pain, tightness, itching, stinging, or tingling (Mawazi *et al.*, 2022) ^[17]. Water-based moisturizers can temporarily hydrate the skin by soaking into the top layer. Oil-based moisturizers form a protective layer on the skin to prevent water loss. Some ingredients can also penetrate deeper into the skin and replenish natural oils. Plant extracts, like polysaccharides and glycosides, can do both. They can attract and hold water due to their chemical structure. Chamomile extract, particularly the part containing quercetin, can improve skin moisture, heal dry skin, regulate oil production, and soothe sensitive skin. Quercetin works by boosting the production of proteins that strengthen the skin's barrier, helping it retain water and reduce sensitivity. Other plant extracts rich in flavonoids, like chrysanthemum, pear cactus, and bamboo, also have excellent moisturizing properties (Zhang *et al.*, 2021) ^[31]. *Centella asiatica* extract is a popular ingredient in cosmetics known for its moisturizing and wound-healing properties. The moisturizing effect comes from compounds called pentacyclic triterpenoid saponins, such as madecassoside. This extract is commonly found in wipes, skincare products, and ointments, making it a valuable treatment for skin conditions like wounds and scars. Liquorice has been reported to improve skin wound healing via angiogenesis increases and collagen deposition (Assar *et al.*, 2021) ^[4]. Aloe vera, rich in vitamins and antioxidants, is celebrated for its ability to soothe and hydrate the skin (Zhang *et al.*, 2015) ^[30].

Anti-aging and Skin Lightening properties

Aging is a natural process where the body gradually deteriorates, leading to a decline in tissue, function, and ultimately, life. Slowing aging involves protecting cells from damage and enhancing tissue structure. This approach can help preserve a youthful appearance and extend a healthy lifespan (Malik *et al.*, 2019) ^[16]. Skin aging is influenced by both internal and external factors. Internal factors, such as the continuous production of reactive oxygen species (ROS) from cellular metabolism, genetic changes, and hormonal fluctuations, contribute to aging. External factors, like sun exposure, smoking, and poor diet, also accelerate skin aging (Yasin *et al.*, 2018) ^[29].

Plant extracts rich in antioxidants, such as phenols, carotenoids, and vitamins, can protect skin from damage caused by free radicals and reactive oxygen species (ROS). These antioxidants help maintain the skin's balance. Plant extracts containing compounds like phenolic quinones, flavonoids, phenylpropanoids, and carotenoids can act as natural sunscreens by absorbing UV light. Liquorice, a well-known skin-whitening agent, can inhibit melanin production

and protect skin from UV damage. Solidoside, found in *Rhodiola rosea*, also has skin-whitening properties (Xie *et al.*, 2024) ^[28]. Recent research suggests that glabridin, a prenylated isoflavonoid derived from liquorice root (*Glycyrrhiza glabra* L.), is a key compound responsible for the plant's skin-lightening properties (Hu *et al.*, 2020) ^[10].

Thymus serpyllum and *Thymus vulgaris*, commonly known as thyme, contain thymol, a compound with anti-aging properties. Thymol helps protect skin by inhibiting enzymes that break down elastin, reducing inflammation, and blocking specific cellular pathways involved in aging (Salehi *et al.*, 2018). Ginseng leaf extract, containing p-coumaric acid, has been shown to reduce melanin production, making it a potential ingredient for treating skin pigmentation (Hu *et al.*, 2020) ^[10].

Capetti *et al.* (2021) ^[6] found that plant extracts from *Cymbopogon schoenanthus* L., *Litsea cubeba* (Lour.) Pers. (a known skin-lightening agent), *Melissa officinalis* L., and *Verbena officinalis* L. can inhibit tyrosinase activity, suggesting potential skin-whitening properties.

Antioxidant properties

Oxidation, a natural byproduct of metabolism, generates harmful free radicals and reactive oxygen species (ROS). When the body's antioxidant defences are overwhelmed, oxidative stress occurs, leading to various skin aging issues (Zhang *et al.*, 2015) ^[30]. Common types of reactive oxygen species (ROS) include superoxide radicals, hydrogen peroxide, hydroxyl radicals, singlet oxygen, and nitric oxide. These highly reactive molecules can damage DNA, alter gene expression, disrupt cellular signalling, induce cell death, oxidize lipids, and degrade proteins (Jonas and Elias, 2001) ^[11].

Green tea extract (*Camellia sinensis*) is rich in polyphenols, particularly catechins, which are powerful antioxidants. Among these, epigallocatechin-3-gallate and epicatechin-3-gallate are the most potent, while other catechins like epicatechin and epigallocatechin also contribute to the antioxidant activity (Senanayake, 2013) ^[20]. Lemon balm (*Melissa officinalis*) extract can neutralize both synthetic and natural free radicals. This suggests that it may help protect against oxidative damage in the body by preventing free radical-induced oxidative stress. Curcumin protects against oxidative damage caused by free radicals, lipid damage, protein damage, and mitochondrial dysfunction. Additionally, curcumin helps regulate the immune system and cellular aging processes (Zia *et al.*, 2021) ^[32]. A study by Chaudhary *et al.*, (2020) ^[7] on *Ocimum sanctum* leaves found that extracts obtained using n-butanol and ethyl acetate solvents were rich in phenolic and flavonoid compounds. These extracts exhibited strong antioxidant activity, likely due to the presence of polyphenols such as luteolin, apigenin, chlorogenic acid, rosmarinic acid, caffeic acid, quercetin, and their derivatives. Rosemary (*Rosmarinus officinalis*) contains rosmarinic acid, a compound with antioxidant properties. Chronic exposure to UV radiation can lead to skin cancer and premature aging. Studies have shown that rosemary extract can help protect the skin from UV damage due to its antioxidant effects (Blumenthal, 1999) ^[5].

Haircare

Medicinal plants play a crucial role in haircare, offering natural solutions for promoting hair health, preventing hair

loss, and addressing scalp issues. Species such as Neem, Henna, Shikakai, Bhringraj, Amla have been used since ancient times in haircare preparations. Neem (*Azadirachta indica*) is a versatile plant containing numerous bioactive compounds like nimbin, azadirachtin, nimbolide, nimbidin, sodium nimbinat, gedunin, salannin, quercetin, and beta-sitosterol. While the entire plant possesses medicinal properties, the leaves are particularly beneficial for hair care. Neem leaves are rich in compounds like nimbin, nimbanene, and 6-desacetylnimbinene, which can help treat various hair problems. Additionally, quercetin and beta-sitosterol, present in neem leaves, exhibit antifungal and antibacterial properties. Azadirachtin and nimbolide demonstrate potent antioxidant activity, neutralizing harmful free radicals (Alzohairy, 2016) ^[3]. Ginger (*Zingiber officinale*) contains bioactive compounds like gingerol, which have vasodilatory properties. This means ginger can relax blood vessels, improving blood circulation to the hair follicles. This increased blood flow can stimulate hair growth, prevent hair thinning, and enhance hair shine and smoothness. Ginger also has potential benefits for treating dandruff and scalp irritation (Tiwari *et al.*, 2021) ^[26]. Curry leaves (*Murraya koenigii*) are a rich source of essential nutrients, including proteins, fiber, minerals, carbohydrates, nicotinic acid, carotene, vitamin C, vitamin A, oxalic acid, and calcium. Additionally, they contain bioactive compounds like crystalline glycosides and triterpenoids. The abundance of beta-carotene and proteins in curry leaves contributes to their ability to prevent hair thinning and hair loss (Khile, 2022) ^[13]. Henna leaves (*Lawsonia inermis*) contain lawsone, a reddish-orange compound that acts as a natural hair dye. This compound, present in dried henna leaves at a concentration of 11.5%, doesn't oxidize hair during the colouring process. Additionally, flavonoids and gallic acid act as natural fixatives, enhancing the colouring process. The carbohydrates in henna create a paste-like consistency, allowing it to adhere to hair effectively. Henna is also believed to prevent premature hair loss by balancing the scalp's pH. Rosemary essential oil can significantly promote hair growth. A study by Panahi *et al* (2015) ^[21] suggests that rosemary oil may be a beneficial treatment for androgenic alopecia. Participants in the study experienced a significant increase in hair growth after six months of using rosemary oil. These findings indicate that rosemary oil may be an effective solution for specific hair growth issues.

Anti Inflammatory and anti-acne properties

Curcumin, a polyphenol compound derived from turmeric (*Curcuma longa* L.), has been used for centuries as both a spice and a medicine. Research has shown that both applying curcumin to the skin and consuming it orally can promote skin health by accelerating wound healing (Zia *et al.*, 2021) ^[32]. Tea tree oil has a broad spectrum of antibacterial properties and reduces skin inflammation due to inhibition of histamine release. *Boswellia serrata* contains boswellic acids (BAs). BAs, while structurally similar to steroids, function differently from painkillers or non-steroidal anti-inflammatory drugs (NSAIDs). They exhibit anti-inflammatory effects by inhibiting the complement system and 5-lipoxygenase. Witch hazel (*Hamamelis virginiana*) is a plant rich in tannins, commonly used in topical treatments for acne due to its safety. Other plants with high tannin content include white oak bark (*Quercus alba*), walnut leaves (*Juglans regia*), *Agrimonia eupatoria*,

Syzygium cuminum, *Ledum latifolium*, *Alchemilla mollis*, lavender (*Lavandula angustifolia*), mullein (*Verbascum thapsus*), *Krameria triandra*, rhubarb (*Rheum palmatum*), St. John's wort (*Hypericum perforatum*), and curly dock (*Rumex crispus*). These plants offer potential benefits for various skin conditions. Blumenthal (1999) [5] demonstrated the effectiveness of a 2% green tea (*Camellia sinensis*) lotion. Green tea's tannins and flavonoids are believed to contribute to its anti-acne properties, as they possess antiseptic and anti-inflammatory effects.

Aromatherapy

Essential oils are valuable therapeutic ingredients used in developing new treatments due to their potential benefits, including anticancer, antiviral, antidiabetic, antibacterial, antioxidant, and aromatherapy properties (Mohamed, 2023). Essential oils are primarily used in pharmaceuticals for aromatherapy and to enhance the sensory appeal of medications. Traditional medicine systems worldwide have long utilized essential oils to treat various health conditions. For instance, eucalyptus oil is used for bronchitis and coughs, sage and clove oils are known for their antibacterial properties, peppermint oil relieves respiratory congestion, and anise and peppermint oils are commonly used as digestive aids (Swamy *et al.*, 2016) [25]. Aromatherapy with lavender essential oil was found to significantly improve working memory function.

Conclusion

The integration of medicinal and aromatic plants (MAPs) into cosmeceuticals has marked a significant shift in the skincare and personal care industries, bridging ancient wisdom with modern scientific advancements. This review highlights the rich potential of MAPs, whose bioactive compounds—such as antioxidants, vitamins, and essential oils—offer therapeutic benefits ranging from moisturizing and anti-aging effects to skin-brightening, anti-inflammatory, and anti-acne properties. As consumer preferences increasingly gravitate toward natural, plant-based, and sustainable skincare solutions, MAPs stand out for their proven efficacy, versatility, and alignment with current wellness trends.

Cosmeceuticals have evolved from traditional remedies into sophisticated products that serve both aesthetic and therapeutic functions. Although regulatory frameworks still lack a standardized classification for cosmeceuticals, the demand for MAP-based products underscores the importance of defining and validating these formulations. This demand also prompts critical considerations for sustainability, conservation, and ethical sourcing to protect the natural resources essential for cosmeceutical production. Through innovations in extraction and formulation techniques, the unique properties of MAPs can be harnessed to create highly effective, multifunctional products that cater to a wide range of skin and hair concerns. Continued research into the bioactive components of MAPs and their mechanisms of action will support the development of novel cosmeceutical applications, offering both cosmetic benefits and a healthier, more sustainable approach to skincare. This intersection of science and nature reaffirms the promise of MAPs in transforming cosmeceutical formulations and advancing holistic skincare in a way that respects both human health and environmental well-being.

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