

REVIEW ARTICLES

Potential use of essential oils in cosmetic and dermatological hair products: A review

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Abstract

Background: Essential oils have great interest among the increasing demand for herbal cosmetics in the market. They are natural sources of biologically active ingredients due to the wide application of such compounds as well as their particular chemical composition. Several researches have evaluated the effectiveness of these bioactive ingredients for use in cosmeceuticals, mainly in both hair scalp and shaft hair damage repair. Thus, the amounts and their associations define the properties of these compositions with interest for hair cosmetic use, such as antioxidant, inflammatory, and antimicrobial activities. Because they are complex compounds, their actions on the skin, hair scalp, and shaft are not yet fully understood.

Aims: The purpose of this review is to highlight the relevant researches and findings on essential oils in hair care.

Methods: In order to achieve this objective, the present work comprises an updated bibliographic review related to essential oils used in hair care.

Results: It was possible to observe that cosmeceuticals containing essential oils applied to the scalp are preferable for topical activity. Also, it was noticed that there are few reports regarding their use in hair shaft. However, it was found that some oils are used to intensify the brightness and fix the hair color.

Conclusions: This work demonstrated that the use of essential oils in both cosmetic products (industrial application) and those associated with oils carriers (as individual protocols) may lead to satisfactory results in the treatment of some scalp dysfunctions.

KEYWORDS

cosmeceutical, essential oil, hair, hair care

1 | INTRODUCTION

Hair treatments involve the use of cosmetic and dermatological products in both hair and scalp. A big demand and interest from

consumers and scientific researches for products containing bioactive and natural compounds have grown in recent years, probably, due to the absence of cumulative chemical substances, which can generate damage to health.^{1,2}

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The main characteristics desired by consumers in the hair care category are natural ingredients, botanical ingredients, and the 'free-from' claims (such as free from salts, sulfates, silicones, parabens, and other perceived like harmful components).³

Essential oils (EOs) may be classified as natural, organic, and vegan, even though there is no specific reference from non-governmental regulatory agencies regarding the definition and classification of these products. According to the Grand View Research report, the global market for organic products is expected to reach \$ 25.11 billion by 2025.⁴ This trend reflects that the society is more concerned about the environmental and health impacts.

Worldwide, several certifying companies issue product seals. Companies that manufacture these products must comply the certifying companies' particular standards, with strict processes of inspection and traceability of input's use, as well as the requirement of the sustainable use of packaging and production supply chains. Thus, the raw material companies and formulators of market products must standardize the concepts involved in defining these types of products and manage all stages of the production process to ensure that their products are socially and ecologically responsible.^{5,6}

Natural EOs do not contain additives, that is, chemical and/or synthetic ones.⁷ Moreover, vegan EOs must contain no component of animal origin and the absence of any animal testing.^{5,7} Organic EOs are produced with 95% of inputs from organic agriculture, grown free from the use of pesticides or genetically modified organisms, that is, a sustainable production.⁶

The EO application has stood out widely in cosmetics as active ingredients or enhancers, perfumery (fragrances), and aromatherapy.^{2,8,9} Furthermore, they have shown great interest in other general areas as human health, mainly in trichology.

Essential oils are soluble in alcohol, ether, and fixed oils, but are insoluble in water. They are usually in liquid form and colorless at room temperature, having a characteristic odor and a lower density than water, except cinnamon (*Cinnamomum verum*), saffron (*Sassafras albidum*), and vetiver (*Vetiveria zizanioides*) oils. According to the French Standardization Agency, EOs are obtained from plant parts by some processes, such as steam distillation, mechanical processes of the citrus epicarp, and distillation.⁹

Essential oils also have markedly different aromas (emitted by the plant of origin) and may be used in therapies like massages, inhalations, and baths and incorporated in cosmetics and dermocosmetics. EOs usually have amazing aromas to be excellent substitutes of the unpleasant odors of most dandruff shampoos, offering a subtle, fresh, and natural aroma.¹⁰

Essential oils can affect the skin cellular function after topical application,¹¹ while they provide antibacterial, antifungal, anti-inflammatory, and antioxidant benefits on the scalp, promoting an increase in the hair shaft density, cleaning effect on the hair bulb, and strengthening of the entire bulb/stem system.^{10,12} Due to these and other reasons (i.e., the natural source precedence and the low toxicity), several cosmetic products containing EOs are available on the market promoting therapeutic action on both scalp and hair shaft conditioning.

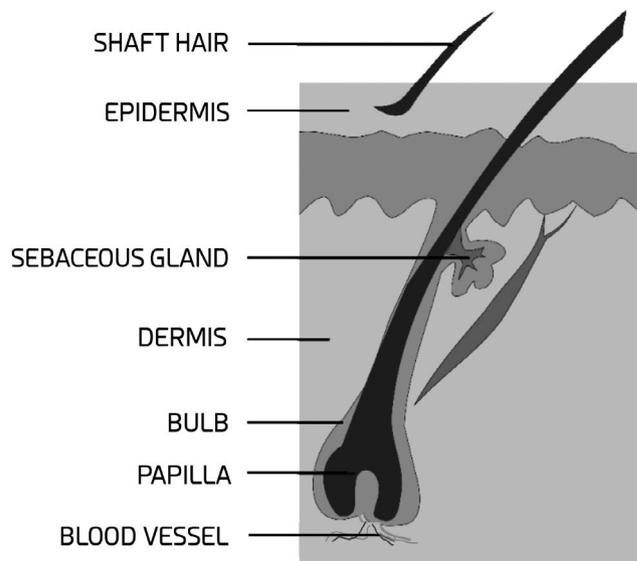


FIGURE 1 Illustration of the hair follicle

Therefore, there should be better understanding of its constituents, the EO chemical and biological properties for further discovery of valuable health applications. However, despite the great interest and importance of the topic, detailed publications focused on the EO use in hair cosmetics are scarce. Thus, we reinforce that EOs should be studied as good alternatives or an effective complement to synthetic compounds in industries, with the main advantage of low or nonexistent side effects reported. In this sense, the relevance of our research is to provide support for health professionals (dermatologists, cosmetic formulators, researchers and aestheticians) on the development of both products and protocols with EOs in the treatment of hair dysfunctions. Additionally, this work includes a broad and updated bibliographic collection of literature with recent patent applications related to EOs in cosmetic and dermatological hair products.

1.1 | Hair anatomy and physiology

Hair is one body part derived from the skin ectoderm.¹³ The scalp is a thick layer formed by both skin and hair (attachments of cutaneous origin), with high hair follicular density (about 100 000–150 000 hairs in normal conditions) and sebaceous glands attached.¹⁴ The hair fiber may be divided into two main regions: hair follicle (root) and hair shaft. Figure 1 shows an illustration of the mentioned portions and annexes. The hair follicle is currently considered a mini-organ, due to its ability to regulate its growth phases, in which the hair shafts are produced. The lowest part of the follicle is the bulb, a region where most of the cellular activity occurs and where the hair thread originates from cell division, being essential for hair growth. Therefore, the bulb is highly irrigated by capillaries due to the necessity to acquire nutrients for the new cells formation.^{15,16}

The shape of the hair shaft is also determined by the bulb, in particular the degree of axial symmetry/asymmetry of the hair matrix.

The stem is a keratinized cellular extension produced in the follicle, which suffer continuous cytoplasm transformation into hair leading to hair growth. The stem extends from the hair follicle to the *stratum corneum*, that communicate it with the external environment. Thus, growth occurs in alternating cycles with periods of both growth and rest throughout bulb life.¹⁷

The hair diameter is also determined by the hair follicle size, which is genetically determined and depends on the migration of specialized fibroblasts into the hair follicle. The more fibroblasts migrate into the hair follicle, the higher final diameter of the hair shaft. During life, the hair follicles enter cycles of growth (anagen phase), regression (catagen phase), rest (telogen phase), and regrowth several times. Thus, the hair length is due to time that the hair follicle remained in the anagen phase.^{15,17}

In general, the skin scalp is coated with fatty acids that are provided from the sebum emulsification from the sebaceous gland, that mixes with water from the sweat glands. Moreover, the sebaceous glands control the transepidermal water loss from the skin and maintain the moisture in the *stratum corneum* (horny cell layers).¹⁸

Despite their shine, body, and texture, the hair shaft is a lifeless lipoprotein structure, which comprises mainly three structures: cuticles, cortex, and medulla. Figure 2A,B shows the scanning electron microscopy (SEM) images of a virgin hair sample.

Figure 2A shows the cuticle, the external part of the fibers, in which condition reflects in their shine and combability.^{19,20} It also shows that repeated aesthetic hair treatments can lead to hair breakage,^{19,21} and other scalp and hair disorders.¹⁶

Figure 2B shows the overlap of the cuticle layers and cortex. The cortex includes fibrillar structures and other components, such as melanin, which provides color to the hair fiber, as well as supports the hair shaft.¹⁹

The medulla is a soft protein layer, centrally positioned in the fiber, consisting of a large number of lipids. Its function in humans is not well known and it is not always found.^{19,20}

Lipids are another constituent of the hair fiber, either as structural or as free lipids, and are formed in the hair follicle. They are basically composed of fatty acids, glycolipids, ceramides, and cholesterol, which provide protection to the hair fiber. Thus, the lipid barrier presence is extremely important to prevent not only the foreign body penetration into the hair structure but also the loose of natural internal moisture hair. Moreover, the formation of the outer hair lipid film as well as the skin is a continuous process by the replacement of the sebaceous lipids removed by the most diverse agents and pathologies.^{19,22}

However, there are internal lipids, such as ceramides, cholesterol, fatty acids, and cholesterol sulfate, which are not derived from sebum.²² The excessive sebum production by the sebaceous glands promotes some processes, such as exfoliation, irritation as well as enhanced concentration of cholesterol, triglycerides and paraffin fractions with lower content of free fatty acids, squalene, and wax esters.²³

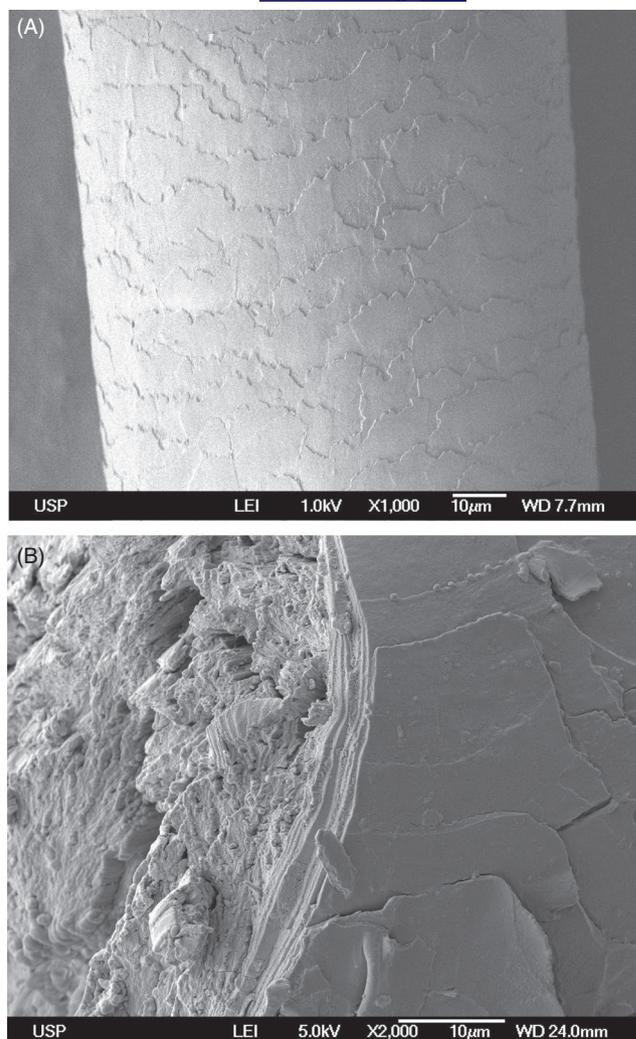


FIGURE 2 Virgin hair sample micrographs, evidencing (A) cuticle (externally) and (B) overlapping cuticle layers and cortex

2 | ESSENTIAL OILS—CHEMICAL COMPOSITION

Essential oils are volatile substances, by-products of plant metabolism, extracted from various parts, such as flowers, grass, herbs, fruit, citrus fruits peel, seeds, leaves, bark, rhizomes, and roots.¹

Essential oils may be oily or lipid-like and frequently have a characterizing strong fragrance. They may contain up to approximately 100 components, although many of them contain from about 20 to 60. They are generally low-molecular-weight compounds with limited solubility in water. These components are from a variety of chemical classes, mainly terpenes (mono-, sesqui-, and di-terpenes) as well as oxygenated compounds (alcohols, oxides, aldehydes, ketones, phenols, acids and esters, among others). Terpenes are also known as isoprenes (hydrocarbons with five carbon units), while terpenoids contain oxygen. The terpene biosynthesis begins with the precursor formation (isopentenyl diphosphate, IPP). EOs also differ in physical properties due to acyclic, bicyclic, or monocyclic

structures. Moreover, EOs are the largest group of natural compounds, with over 30,000 known structures.^{24,25}

Among the terpenes, the monoterpenes are the most representative molecules constituting 90% of EOs with a big variety of chemical structures.¹

Natural origin terpenes have been highlighted in the cosmetic area due to not only their low irritation power but also their lipophilicity that enhance skin permeation process. Indeed, several studies have proved the terpene efficacy as facilitating skin permeation agents.^{26,27}

The mechanism of terpene skin permeation includes the network of hydrogen bonds between the ceramides that can be lost by hydrogen bond competition. Thus, the accumulation of terpenes in the skin layers facilitates permeation by the *stratum corneum* and, in some cases, it can easily reach the blood circulation in vivo.²⁸

Furthermore, it is expected that hydrocarbon terpenes, such as limonene, exhibit a better penetration enhancement effect for lipophilic drug molecules. Conversely, the terpenes with polar groups, such as menthol, 1,8-cineole, provide a better penetration enhancement effect for hydrophilic drug molecules.²⁶

Many studies have discussed several EO properties and even that each EO has a set of potential therapeutic properties based on its chemical composition.¹ These therapeutic properties are defined by the chemical composition in which, generally, the major components reflect quite well not only the biophysical but also the biological features of EOs from which they were isolated.²⁹ However, synergistic effects of the several molecules found in EO are not clear yet if compared to the action of only one or two main isolated components. In some cases, the properties of the individual compounds may seem to be antagonistic to each other. However, such effects allow EOs to act in a balanced manner with apparently no side effects.¹ Table 1 provides a summary of the main chemical components in EOs that have therapeutic effects.

2.1 | *Rosmarinus officinalis* (Rosemary oil)

Rosemary oil is considered an important material in not only medicinal but also aromatic areas. It generally contains moderate levels of 1,8-cineole (12%–61%), camphor (5.8%–24%), α -pinene

(0.4%–14.2%), verbenone (4.4%–45.2%), and borneol (1.6%–8.3%) depending on the location and seasonal variations.³⁰

It has the efficacy to reduce microbial contamination in aqueous emulsions. It has been largely used based on the particular biological properties, such as vasodilation (stimulates blood circulation in the hair follicle); antibacterial, antioxidant, cytotoxic, antimutagenic, antiplogistic action as well as chemopreventive in traditional medicine and cosmetics products.^{30,31} However, it should not be used during pregnancy due to its abortive effect. It has neurotoxic effect by the high camphor content (from 6.4% to 30%) being not recommended for epileptics.¹ It should be cautiously used in individuals with primary hypertension and diabetes.³²

2.2 | *Eucalyptus globulus* (Eucalyptus oil)

Eucalyptus oil is well known for benefitting the respiratory system and having fatigue recovery effects,³³ showing anti-inflammatory and decongestant properties.⁸

It was reported that the *Eucalyptus globulus* EO had antibacterial activity against Gram-positive and Gram-negative bacteria resistant to antimicrobial agents commonly used, remarking its potential use as a preservative.³⁴ It includes 1,8-cineole (eucalyptol; not less than 70%), limonene (4%–12%), α -pinene (2%–8%), α -phellandrene (<1.5%), β -pinene (<0.5%), and camphor (<0.1%).³⁵

Its terpenes are the most abundant ones in the eucalyptus leaves, which function is facilitating the ecological interactions as well as providing the characteristic and pleasant odor, with the particular economic and industrial value added.³⁶

2.3 | *Melaleuca alternifolia* (Tea tree oil)

The tea tree oil, also known as melaleuca oil, is effective in the treatment of furuncles, psoriasis, and fungal infections, as well as antimicrobial with broad-spectrum, anti-inflammatory, antioxidant, and anti-skin cancer potential agent.^{2,8,11}

Its major component is terpinen-4-ol,^{2,38} which provides antimicrobial activity. It also contains as main components: terpinen-4-ol

TABLE 1 Main organic classes in essential oils and their therapeutic effects^{1,9,24}

Chemical class	Therapeutic action	Examples
Aldehydes	Sedative, anti-inflammatory, antiviral, calming the nervous system, hypotensors, vasodilators	Neral; citronellal; geranial, cuminal; cinnamal; others.
Alcohols	Stimulating; anti infectious, strongly bactericidal, antiviral, analgesic, fungicidal	Geraniol; lavandulol; piperitol; pulegol, α -terpineol; linalool; borneol; sclareol; menthol; thymol; viridiflorol; others
Esters	Antispasmodic, balancing, antifungal	Benzyl acetate; linalyl acetate; others
Oxides	Expectorants, antiviral properties	Cineole; 1,4-cineole; linalool oxide; others.
Ketones	Cell regenerative, mucolytic, neurotoxic	Pulegone; menthone; piperitone; thujone; camphor; verbenone; germacrone; others.
Phenols	Strong antibacterial, immune stimulating, warming	Chavicol; <i>p</i> -cresol; carvacrol; others.

(39.1%) and delta-terpinene (20.4%).³⁷ Moreover, alpha-terpinene, 1,8-cineole, p-cymene, terpinolene, a-terpineol, among others, were reported.^{1,37}

Tea tree oil is incorporated as an active ingredient in many topical formulations to treat cutaneous infections due to their ability to reduce the tumor necrosis factor production.³⁸

2.4 | *Mentha piperita* L. (Peppermint oil)

The main components of peppermint oil (*Mentha piperita* L.) reported were menthol (30%–50%), menthone (15%–30%), menthyl acetate (2%–9%), neomenthol (4%–8%), 1,8-cineole (4%–7%), isomenthone (2%–4%), and menthofuran (1%–7%).³⁹

Menthol is an organic compound having anesthetic properties that help soothe the skin discomfort. Furthermore, it can increase the sensitivity of cutaneous cold receptors by being able to modulate the Ca²⁺ currents of neuronal membranes, as well as increase penetration more effectively, especially when associated with limonene.⁴⁰

Peppermint oil has antiviral, antimicrobial, antibacterial, and anti-inflammatory properties.¹ It also has high antifungal potential, antioxidant activity, antiallergenic, and antitumor actions.⁴¹ It is widely used in cosmetics, mainly in pharmaceutical products and male grooming.

2.5 | *Matricaria chamomilla* L. (Chamomile oil)

Chamomile is well reported with antioxidant action, attributed to the sesquiterpene known as chamazulene. It can reduce inflammation due to the presence of flavonoids (mainly polyphenols).⁴²

Polyphenolic compounds have antioxidant properties, that is, the ability to counteract the harmful effects of reactive oxygen species (ROS), which are produced during physiological cellular metabolism and also by external factors like UV radiation and pollutants.⁴³ This oil also is safe for skincare, with anti-inflammatory, anti-erythema, antipruritic, and calming effects.¹¹

It also contains, farnesene, α -bisabolol, and oxygenated sesquiterpenes, such as bisabolone oxide A and bisabolol oxide A and B.⁴²

2.6 | *Lavandula angustifolia* (Lavender oil)

Lavandula officinalis/angustifolia contain numerous monoterpenes (cyneol, borneol, geraniol) and also organic acids, coumarins, mineral salts, and tannins, which are responsible for the lavender pharmacological activity.⁴⁴ The main components of lavender essential oil reported were linalyl acetate (43.1%) and linalool (32.7%).³⁷

It is traditionally used as an antiseptic agent, relaxant, carminative, and sedative in aromatherapy.³⁷ Its antimicrobial properties may help in some treatments, such as viral, bacterial, and fungal overgrowth in the skin by limiting the *Malassezia* spp. growth. Moreover,

its anti-inflammatory and analgesic properties may relieve pain and soothe irritated skin.⁴⁵

It was also possible to verify the antioxidant potential of the 1,8-cineole (48%) and menthol (39%) also present in this essential oil in another study.⁴⁶

2.7 | *Citrus bergamia* (Bergamot oil)

Bergamot oil contains several bioactive molecules in two fractions from the total: volatile (93%–96%) and non-volatile (4%–7%).⁴⁷ The first one includes monoterpene limonene (25%–53%) and high quantities of oxygenated compounds, such as linalool (2%–20%), linalyl acetate (15%–40%), γ -terpinene, and β -pinene.⁴⁸

Limonene has shown effectiveness as a transdermal delivery enhancer, increased human skin permeability, and decreased lag time.⁴⁹ The non-volatile fraction contains pigments, waxes, coumarins, and psoralens, as well as bergamottine.⁴⁷ Limonene properties include antimicrobial, anti-inflammatory, antiproliferative, and analgesic activity, including effects on the cardiovascular central nervous system, as well as in diabetes, and bone and skin metabolism. Therefore, it should be used with caution when topically applied (usually associated with vegetable oils and directly on the skin).⁵⁰

As an interesting result, some studies demonstrated that bergamot essential oil has important results in the treatment of psoriasis and hair growth.⁵¹

2.8 | *Pelargonium graveolens* (Geranium oil)

The geranium oil (*Pelargonium graveolens* L.) shows dominant volatile compounds, such as citronellol (38.0%), geraniol (16.0%), citronellyl (10.4%), and linalool (6.5%).⁵²

Several studies show that EOs and extracts from *Pelargonium graveolens* have activities, such as antibacterial and antifungal,⁵³ antioxidant, and antitermitic.⁵⁴ It also has anti-inflammatory, astringent, cicatrizing, homeostatic properties, and antidiabetic properties.¹ It was considered as a cleansing and toning to be used to treat greasy skin and eczema.^{11,55}

3 | ESSENTIAL OILS IN THE SKIN MICROBIOTA

Several factors can alter the natural microbiota of the skin and its attachments, affecting the resident surface colonies, such as environmental changes, geographic location, and the use of both medicines and cosmetics. The maintenance of a state of the microbiota physiological balance is essential and the formation of a dysbiotic state affects the defense functions, such as the skin protective barrier, leading to pathological states. Thus, the EO use helps the physiological balance due to their lipophilic characteristic with a consequent

formation and maintenance of a protective film in the *stratum corneum* as well as the skin microbiota.^{56,57}

Essential oils obtained from plants such as lavender (*Lavandula angustifolia*), thyme (*Thymus vulgaris*), peppermint (*Mentha piperita* L.), cajuput (*Melaleuca cajuputi*), cinnamon (*Cinnamomum zeylanicum*), clove (*Syzygium aromaticum*), eucalyptus (*Eucalyptus globulus*), sage (*Salvia officinalis*), and tea tree (*Melaleuca alternifolia*) have antimicrobial activities. This effect is due to the presence of phenolic, aromatic, or alcoholic groups, which naturally prevents the development of pathogenic microorganisms, with emphasis on Gram-positive bacteria.⁵⁶

However, there is not a lot of researches about the relationship between microbiomes and EOs, requiring new approaches on the subject.⁵⁷

4 | ESSENTIAL OILS IN HAIR AND SCALP DISORDERS

Recurrent aesthetic treatments on the hair may damage the hair shaft structure and also promote scalp disorders.^{1,21} However, some dysfunctions may be caused by endogenous factors, such as systemic diseases and others related to hair and scalp, that is, dandruff, seborrheic dermatitis, psoriasis, non-healing alopecia, androgenetic effluvium, areata, and telogen.¹⁶

Many of these pathologies are related to excessive oil in the hair, which may be associated with the accumulation or degradation of cosmetic hair products or by-products that generates intense scalp sweating.⁵⁸ Regardless of the causes, excessive sebum in the scalp produces the ideal environment for the development and proliferation of pathogenic microorganisms, such as *Malassezia* spp., whose action may result in itching, dandruff, visible inflammation, reduced peripheral blood circulation, and hair loss.^{16,59}

Currently, there are several types of treatments related to hair and scalp disorders, mainly with the use of synthetic products like minoxidil, as in the hair loss treatment.⁵⁹

According to Farboud et al.,⁵⁸ no product applied locally can cure acute seborrhea, and only relatively toxic synthetic compounds with serious adverse effects can reduce the secretion of sebaceous glands, such as anti-inflammatory agents as zinc pyrithione, ketoconazole, and terbinafine. However, it is reported that some disorders may be treated with the use of specific natural ingredients incorporated or not into cosmetic formulations, due to reduced adverse effects, fewer hypersensitivity reactions, and, in some cases, higher effects than the synthetic ones.^{13,59}

The field of cosmetic dermatology is growing with the association between medical treatment of hair diseases and traditional cosmetology. Thus, EOs have become increasingly popular in cosmetic and medicated hair products due to the growing number of reports regarding their beneficial effects on the scalp and hair.¹¹

Particularly in trichology, several EO properties were reported as an active ingredient and pleasant sensorial properties in cosmetic formulations. Among the main properties, EOs have antioxidant

activity against free radicals; anti-inflammatory and antimicrobial activities⁶⁰; anti-pollution⁶¹; anti-dandruff⁶²; and anti-hair loss activities.^{63,64}

The EO active ingredients can penetrate in the scalp quickly, nourish the deep hair follicles, supplement the nutrition, stimulate the hair follicle growth, moisturize the hair roots, strengthen the hair, and even effectively remove unwanted metabolites that block the pores.⁶³

Seborrhea is a pathology that can cause oiliness on both scalp and hair. Currently, there are few compounds capable of reducing sebaceous gland secretions.⁵⁸ However, EOs may alleviate the onset of seborrheic dermatitis and inhibit the pathology proliferation. Thus, therapies involving the EO topical use may represent an interesting alternative in relieving some hair disorders.⁴⁶

The use of a few EO drops in the final hair rinse or added directly to shampoo was reported. EOs from rosemary (*Rosmarinus officinalis*), West Indies bay (not specified), and chamomile (*Matricaria chamomilla*) helped the conditioning and stimulated the hair growth; lavender (*Lavandula angustifolia*) may be used to repel lice and fleas, while bergamot (*Citrus bergamia*), and the tea tree (*Melaleuca alternifolia*) may control dandruff.⁶⁵

Some EOs can penetrate the hair follicle and bind to receptors that stimulate hair growth and are the safest option in the alopecia treatment. However, drug interventions with EOs are not well established in the scientific literature.¹³

Chamomile and rosemary are known to improve hair growth and prevent hair loss.^{8,11,65,66} Rosemary oil showed tonic skin properties, promoting a calming effect and hair growth, and the scalp stimulation, thus becoming a proper treatment for both dandruff and oily hair.⁶⁷

Moreover, 3.0% peppermint oil (*Mentha piperita* L.) facilitated hair growth, have promoted the conservation of the dermal papillae vascularization and contributed to the stage early anagen induction. They also reported the effective stimulus for hair growth in an animal model and that it may be used as a therapeutic or preventive alternative for hair loss in humans.²⁸

The clinical efficacy of rosemary oil (containing at least 3.7 mg 1,8-cineole per ml of the product) as well as 2% hydro-alcoholic minoxidil were reported in patients with androgenetic alopecia (AGA). Such EO was as efficient as minoxidil against AGA and it reduced the scalp itchiness when compared with the group that used minoxidil. They reported the positive effect of the EO antioxidant properties since AGA promotes oxidative stress and generates a large number of free radicals. Also, it favors the blood circulation in the hair follicle because of its vasodilation properties.⁶⁴

The *Cinnamomum zeylanicum* L. EO acts as an important antioxidant due to the phenolic and polyphenolic substances. GC-MS analysis identified cinnamaldehyde (96.8%), α -copaene (0.2%), α -muurolene (0.11%), *p*-methoxycinnamaldehyde (0.6%) and δ -cadinene (0.4%).⁶⁸ It is a broad-spectrum bactericide, fungicide, and parasiticide. In addition, it delayed the oxidative changes in formulations with a concomitant extension in the product shelf life. Also, the free radicals elimination to inhibit the skin lipid peroxidation can activate the blood circulation that aids hair growth. Moreover, it also

removes dandruff. However, the pure application in the scalp is contraindicated because it has irritant potential.^{68,69}

4.1 | Oils carriers of the EOs and formulations

Lavender (*Lavandula angustifolia*), tea tree (*Melaleuca alternifolia*), bergamot (*Citrus bergamia*), copaiba (*Copaifera officinalis*) and ylang ylang (*Cananga odorata*) EOs may be directly applied to the scalp, even without dilution because they have low risk of sensitivity and irritation.^{70,71} However, some EOs contain many concentrated and potent components with potential irritation and discomfort in the sensitive skin. Therefore, it is recommended to dilute the EOs in a carrier substance (vehicle) to avoid the harmful effects related to the concentrated ingredient.^{70,72}

The most potent EOs are safe and comfortable for topical application, without damaging the tissues. EOs are mimetic to human skin and scalp and have been used by health professionals and aesthetic clinics in scalp disorders treatments.^{10,70-72}

Many types of oil carriers are currently available. For instance, vegetable oils such as avocado (*Persea americana* Mill.), coconut (*Cocos nucifera* L.), sweet almond (*Amygdalus communis* L.), argan (*Argania spinosa*), wheat germ (*Triticum vulgare*), sunflower (*Helianthus annuus*) and grape seed (*Vitis vinifera*) can prevent the rapid volatilization of EOs, and even prolong their action.¹⁰

The safest way for topically EO application is following the specific instructions based on scientific data and the suitable carrier for its dilution.^{70,72} In addition to the use of isolated or associated with carrier substances, there are cosmetic formulations that promote specific benefits for both scalp and hair shaft. Generally, shampoos only clean both hair and scalp, but their formulations may be adapted to the hair shaft and scalp condition, hygienic habits and other specific problems, such as seborrheic dermatitis, dandruff and androgenic alopecia.³⁷

The EOs, such as lavender (*Lavandula angustifolia*), bergamot (*Citrus bergamia*), and geranium (*Pelargonium graveolens*) incorporated into shampoo formulations with pH 5.5–6.5, can show synergistic effects. For instance, purifying the scalp, reduction of irritation, control of both dandruff and excessive oiliness, thus strengthening the hair fiber, stimulating the hair follicles (improves circulation) and, consequently, accelerating hair growth.

Moreover, it is important to control the scalp oiliness excess that promotes unpleasant odors and even difficult the proper hair growth. Therefore, the presence of some aromatic substances in the EOs coupled to their particular chemical composition in hair formulations promotes physical, mental, and emotional balance, while adding pleasant odors to fiber and scalp.^{28,46}

4.2 | Blending of oils in the benefits to scalp

It is also known that, in addition to the main effect produced by a specific component of a single EO, there is also an effect enhancement after the application of two or more EOs in a mixture.¹ Therefore,

an alternative in therapy is the association of some EOs, with an expected synergistic effect.

The efficacy of the following EOs thyme (*Thymus vulgaris*, two drops, 88 mg), rosemary (*Rosmarinus officinalis*, three drops, 114 mg), lavender (*Lavandula angustifolia*, three drops, 108 mg), and cedarwood (*Cedrus atlantica*, two drops, 94 mg) in a mixture of carrier vegetable oils with both jojoba (*Simmondsia chinensis*, 3 ml) and grape seed (*Vitis vinifera*, 20 ml) was tested in the treatment of scalp alopecia areata. Such results suggested that this combination is safe and effective in the alopecia areata treatment and can be used as a therapeutic alternative.⁶⁶

Essential oils from lavender and tea tree have demonstrated activity in isolated form.¹ Moreover, there is no clinical evidence regarding the use of thyme oil isolated for hair loss.⁷³ However, its use has been reported as biologically active with antibacterial, antifungal and antioxidant activity.⁶⁶ Furthermore, phenolic compounds isolated from thyme are effective in protecting biological systems against various substances that promote oxidative stress.⁷⁴

Rosemary EO is also known for its vasodilating properties, which promote increased blood circulation in the hair follicle.⁶⁴ *Lavandula angustifolia* EO has analgesic activity, soothing, anti-inflammatory, antiseptic and healing properties, while *Cedrus atlantica* EO has healing, antiseptic and stimulating properties for skin and scalp problems.¹

Moreover, it was studied the anti-inflammatory and antibacterial activities of a mixture of some EOs, which concentrations as described in parts by weight as follows: rosemary (*Rosmarinus officinalis*, 10–20 parts), Mediterranean cedar (*Cedrus libani*, 5–10 parts), lavender (*Lavandula angustifolia*, 5–10 parts), ylang ylang (*Cananga odorata*, 5–10 parts), cedarwood (*Cedrus atlantica*, 5–10 parts), geranium (*Pelargonium graveolens* L., 5–10 parts) and orange (*Citrus sinensis*, 10–20 parts). Such study revealed the blood circulation acceleration in the scalp region, alopecia reduction, sebum production regulation, dandruff removal and the scalp ulcers treatment.⁷⁵ Although the species has not been clearly specified in this document, Mediterranean cedars have been reported as lebanon cedar (*Cedrus libani*) and have the greatest genetic diversity within the population of all cedars.⁷⁶ Thus, this EO is used in perfumery and personal hygiene due to its pleasant and persistent fragrance. It is also antiseptic for skin diseases and has antibacterial and antifungal properties.⁷⁷

Furthermore, the EO combination containing cypress, geranium, lavender, lemon, tea tree, thyme, clary sage, rosemary, sandalwood, palmarosa, chamomile, eucalyptus, basil, and ylang-ylang was incorporated in a shampoo to minimize both hair loss and dandruff. However, the species are not specified in such document.³³

The literature also related the EO antioxidant activity of the following species: *Eucalyptus camaldulensis*, rosemary (*Rosmarinus officinalis*), coriander (*Coriandrum sativum* L.), juniper (*Juniperus drupacea* L.), cumin (*Cuminum cyminum*), basil (*Ocimum basilicum* L.), cinnamon (*Cinnamomum zeylanicum*), clove (*Eugenia caryophyllata*), and thyme (*Thymus spathulifolius*).^{8,78,79}

Moreover, it was also reported the toxicity of the 1,8-cineole monoterpene (one of the main derivatives from *Eucalyptus*

globulus leaf oil), which is responsible for the effectiveness in the lice treatment.⁸⁰

The EOs of tea tree (*Melaleuca alternifolia*), rose (*Rosa damascena*), pomelo (*Citrus grandis* Peel) and fennel (*Foeniculum vulgare*) have been described as moisturizers, while thyme oils (*Thymus vulgaris*), lavender (*Lavandula angustifolia*) and sage (*Salvia sclarea*) are indicated against dandruff and alopecia.^{33,81}

Another EO association with unspecified species, such as lavender, allspice (*Pimenta officinalis*), sage, thyme, rose, ylang ylang, juniper (*Juniperus communis*), basil, and mint, was indicated for the seborrheic alopecia treatment.⁸² It was reported that the ylang ylang EO stimulates the skin, corrects disturbances in sebaceous secretion, stimulates hair growth and smoothness. Moreover, the juniper EO improves the sebum on the scalp; the basil EO slows skin aging; clean the sebum and nourish the scalp; and the peppermint EO refreshes and eliminates body toxins and relieves itching, inflammation as well as burns.^{63,82}

Geranium flower (*Pelargonium graveolens*) EO was used as a regulator of skin secretion, maintaining the oil balance.^{33,63} The combination of EOs, such as wheat germ (95 parts), rosemary leaf (one part), geranium leaf (two parts), lavender (one part), and jasmine flower (*Jasminum grandiflorum*) (one part), was added to the hair dye to increase color durability and reduce damage to the hair process.⁸³

The EO combination containing sweet orange, bergamot palm, lemon, grapefruit, citronella (*Cymbopogon winterianus*), Taiwanese cypress wood, pine powders, and German chamomile helped in controlling the oil, relieved itching with anti-itch effect as well as allergic and removed dandruff.⁸⁴

Kim et al.⁵⁹ adopted an in vitro method with extract of yeast *Malassezia globosa*, arachidonic acid, linoleic acid and dihydrotestosterone as inductors of seborrheic dermatitis with the EOs from *Cinnamomum zeylanicum* (cinnamon), and *Mentha arvensis*. These EO had an inhibitory effect on sebum synthesis and the growth of the yeast *M. globosa*, suggesting effectiveness in the relief of protection from seborrheic dermatitis of the scalp. The authors verified important antioxidant and antimicrobial activities, promoting effectiveness in the treatment and relief of symptoms. Another advantage of such EOs in the hair is their ability to provide shine, conditioning effects and also to protect and enhance the scalp health.⁶⁵

Lemon oil (*Satureja montana*) has been used as an anti-pollution agent for keratin fibers, in particular for hair.⁶¹ Moreover, it was demonstrated that 5% of the tea tree oil in the shampoo was effective in reducing dandruff and is well tolerated by patients.⁸⁵

It was reported the use of tea tree oil, as a popular ingredient, in a variety of household products and cosmetics, including shampoos, massage oils, skin and nail creams.³⁸

Essential oil of geranium prevents split ends and promotes brightness and softness to the hair.¹⁰ As EO are a mixture of volatile lipophilic constituents, EOs have high affinity for fat or for lipophilic substances, forming a film on the hair shaft, which promotes emollience, brightness and reduces electrical charges.⁸⁶

Essential oils from lavender (*Lavandula angustifolia*), mint pepper (*Mentha piperita*), cedarwood (*Cedrus atlantica*), rosemary

(*Rosmarinus officinalis*), eucalyptus (*Eucalyptus globulus*), tangerine (*Citrus rind*), and tea tree (*Melaleuca alternifolia*) have also been reported by promoting shine in the hair stem.⁷⁰

Table 2 summarizes the main EOs with plant origin and their dermocosmetic and cosmetic applications in the literature.

4.3 | Toxicity of the essential oils

The body regions with a large number of pilosebaceous orifices, highly vascularized and the mucous membranes are highly permeable areas for EO penetration due to their high lipophilic nature.⁸⁸

Pure EOs are often highly toxic.⁸⁹ Their toxicity involves the dose, composition, dilution, frequency of use and application.⁹⁰ The most frequent undesirable effects are those resulting from direct contact of EOs with the skin, such as dermal reactions, contact dermatitis, phototoxicity/photosensitivity reactions by sun exposure,^{55,91} In particular, EOs containing cinnamic alcohol, aldehyde, eugenol, and baptapene have induced several effects from blemishes to burns.⁹²

In other words, applying undiluted EOs is potentially dangerous, especially on diseased, damaged, or inflamed skin, once these oils are highly concentrated and a greater amount will be absorbed and worsen the skin, and even dermal sensitization reactions could be triggered.⁸⁹ However, proper use drastically reduces potential risks. When applied directly into the skin or scalp, the correct procedure is to occlude/dilute a small amount in base oil (vegetable oil) or clays (white, green, and black).^{70,71} Table 3 resumes possible carrier oils and toxicity of some EOs.

5 | CONCLUSIONS AND PERSPECTIVES

Our study showed that EOs are so attractive to assist trichologists, doctors, as well as health professionals in their patients' treatment. We summarized the EOs used in cosmetics for scalp and hair shaft care. Thus, the studies demonstrated that the oils have interesting effects, mainly, in the scalp, such as anti-hair loss, anti-inflammatory, anti-bacterial, antioxidant, anxiety-relieving and stimulant. Furthermore, their lipophilic characteristic aid maintaining the physiological microbiota balance of both scalp and skin, since once modified can affect the normal defense functions, mainly the skin protective barrier, leading to pathological states. Other studies and researches demonstrated that EOs have promoted shine, emollience, pleasant scent, and durability of the color dye in the shaft hair.

These cosmetic ingredients can be used isolated directly on the skin, in association with other essential oils, diluted in carrier substances (such as vegetable oils), and even incorporated into dermocosmetic formulations for the scalp treatment. They can also in specific functions, such as the regulation of sebum secretion, hair growth stimulation, relief the scalp inflammation, oil control itching, among others, when incorporated into several formulations. Among cosmetics forms, shampoos, and tonics containing EOs are the main products of interest aimed to clean the hair shaft and scalp. They are

TABLE 2 Plant-derived essential oils and their applications

Essential oil	Plant source	Hair/scalp application	Cosmetic type	Concentration w/w (%) ^a
Rosemary	<i>Rosmarinus officinalis</i>	Prevent hair loss and hair growth, promote blood circulation, stimulate hair regeneration; astringent of the scalp, oil control itching, smooth the scalp. ^{33,64} Terpenes with agents that facilitate skin permeation ^{26,27}	Hair tonic and shampoo	0.5%–1.0%
Eucalyptus	<i>Eucalyptus globulus</i>	Agent against louse peniculids ⁸⁰ ; control sebum; good for scalp ³³	Moisturizing cream and shampoo	1.0%–5.0%
Lemon Mountain Savory	<i>Satureja montana</i>	Anti-dandruff agent, in particular cells caused by yeasts of the genus <i>Malassezia</i> . Restore the scalp ecorflora ⁶²	Shampoo, gel or lotion.	0.5%–5.0%
Tea tree	<i>Melaleuca alternifolia</i>	Anti-dandruff agent, effective against seborrheic dermatitis ⁸⁵ ; effective for dry scalp; inflammation scalp ³³	Hair tonic and shampoo	2.0%–3.0%
Peppermint	<i>Mentha piperita</i>	Contract microvessels, relieve itching, inflammation and burns ⁸³	Shampoo and conditioner	0.5%
Chamomile	<i>Matricaria chamomilla</i>	Promote hair growth ⁶⁵	Hair tonic, shampoo and conditioner	0.5%–10.0%
Lavender	<i>Lavandula angustifolia</i>	Stimulate the hair growth ^{33,66}	Hair tonic, shampoo and conditioner	0.5%–5.0%
Bergamot	<i>Citrus bergamia</i>	Control and eliminate seborrhea and alopecia on the scalp ⁸⁷	Hair tonic	0.5%–6.0%
Geranium	<i>Pelargonium graveolens</i>	Regulator the secretion of the skin ^{33,63} ; balance scalp oiliness; improve blood flow; anti-hair loss; anti-dandruff agent ³³	Shampoo and conditioner	0.5%–1.0%
Cedarwood	<i>Cedrus atlantica</i>	Promote hair growth ⁶⁶	Hair tonic and shampoo	0.5%–2.0%
Basil	<i>Ocimum sanctum</i>	Regulate the grease ⁸²	Shampoo and conditioner	2.5%–5.0%
Ylang-Ylang	<i>Cananga odorata</i>	Regulate sebum secretion of skin, stimulate hair growth, ^{33,63,82} relieve scalp inflammation, make the hair shiny ⁶³ ; anti-hair loss, anti-dandruff ^{33,70}	Conditioner and hair tonic	0.8%–2.0%
Thyme	<i>Thymus vulgaris</i>	Promote hair growth ⁶⁶ ; stimulate blood circulation of the scalp, strength the hair roots, alleviate dandruff and anti-hair loss ³³	Hair tonic and shampoo	0.5%–5.0%

^a% values to be used incorporated in cosmetic formulations.

TABLE 3 Characteristics of the essential oils (toxicity and possible carrier oils)^{55,90,91}

Essential oil	Plant source	Toxicity	Carrier oil
Basil	<i>Ocimum sanctum</i>	Photosensitive or aggressive to skin	Vegetable oil from jojoba, grape seed, sesame
Bergamot	<i>Citrus bergamia</i>	Phototoxic, sensitizing, which can cause burns, allergic dermatitis and skin irritation.	Vegetable oil from coconut, sweet almond, jojoba, grape seed, sesame
Cedarwood	<i>Cedrus atlantica</i>	Skin irritation	Vegetable oil from coconut, jojoba
Chamomile	<i>Matricaria chamomilla</i>	NI	Almond vegetable oil
Eucalyptus	<i>Eucalyptus globulus</i>	Nausea, vomiting and diarrhea. In extreme cases, it can lead to seizures and death.	Vegetable oil from Wheat Germ, flaxseed
Geranium	<i>Pelargonium graveolens</i>	Skin allergy and irritation	Vegetable oil from avocado, jojoba
Lavender	<i>Lavandula angustifolia</i>	NI	Vegetable oil from wheat germ, jojoba, avocado, sesame, coconut, almond, grape seed, sesame
Peppermint	<i>Mentha piperita</i>	Contact dermatitis	Vegetable oil from coconut, sweet almond, jojoba, grape seed, sesame
Rosemary	<i>Rosmarinus officinalis</i>	Neurotoxic and convulsive. Contraindicated in pregnant women, asthmatics, people with a history of epilepsy and hypertension.	Vegetable oil from avocado, jojoba
Tea tree	<i>Melaleuca alternifolia</i>	Allergies can occur, being rarer in high quality oils with cineole levels below 2.8%	Vegetable oil from wheat germ, jojoba, avocado, sesame, coconut
Thyme	<i>Thymus vulgaris</i>	Aggressive to skin	Vegetable oil from wheat germ
Ylang-Ylang	<i>Cananga odorata</i>	Toxic and neurotoxic action, sensitizing, may cause allergies and skin irritation	Vegetable oil from avocado, jojoba

Abbreviation: NI, no information available.

used according to their state; hair quality; habit of taking care of the hair, specific problems, among others.

Finally, it is important to highlight the need for further studies on the use of essential oils in hair treatments, mainly due to the great variation in the concentration of actives due to the method of extraction, collection time, climatic conditions, geographic location, lack of standardization, low stability and reduced activity when compared to synthetic actives.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTION

Ursulandréa Sanches Abelan and Andressa Costa de Oliveira: Conception, design, acquisition and analysis of data and drafting the manuscript. Érica Savassa Pinto Cacoci: Conception, design and drafting the manuscript. Tércio Elyan Azevedo Martins: Acquisition and drafting the manuscript. Virginia Mansanares Giacon and Maria Valéria Robles Velasco: Review of important intellectual content. Cibele Rosana Ribeiro de Castro Lima: Supervision, conception, design, acquisition and analysis of data, drafting the manuscript and review of important intellectual content.

ETHICAL APPROVAL

This is a review paper, and an ethics committee is not necessary.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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