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Review Paper

From Ayurveda to Advanced Cosmeceuticals: The Expanding Role of Santalum album

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ABSTRACT

Sandalwood (*Santalum album*) is one of the most priced aromatic trees and has been used intraditional and modern cosmetics for its therapeutic and cosmetic effects [1]. The benefits of sandalwood in the development of cosmetics including creams, lotions, face packs, and perfumes are increased as more and more consumers are opting for herbal cosmetics and skincare products [2]. It is found to possess bioactive chemical compounds such as α -santalol and β -santalol, which have shown anti-inflammatory, antimicrobial, antioxidant and cooling effects on the skin [16,29,35]. The use of sandalwood in different cosmetics such as anti-acne face packs and anti-aging creams, is useful wing to its soothing properties [12,22].

INTRODUCTION

Sandalwood (*Santalum album*) is a slow growing evergreen tree from the family Santalaceae which is native to India [16,34]. It is best known for its scent and fragrant heartwood and oil. [4,28] The invaluable oil has been used for centuries for medicinal purposes and in the preparation of cosmetics [24,31]. Sandalwood oil contains active components which have a soothing, cooling, and healing effect on the skin [3,21]. These attributes are why sandalwood oil is found in face creams, anti-acne and anti-aging formulations [9,36,37].

Botanical classification of Sandalwood [17,25]

Name : Sandalwood

Biological Name : *Santalum album*

Family : Santalaceae

Species : *S. Album*

Genus : *Santalum*

Type : Plantae

Physicochemical composition of Sandalwood [14,39]

Sandalwood's therapeutic cosmetic value is derived from a rich array of bioactive secondary

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metabolites present throughout the plant, including the leaves, bark, fruits and seeds.

Category	Examples	Function
Sesquiterpenes	α -santalol, β -santalol	Anti-inflammatory, antimicrobial.
Essential oils	Santalol compounds	Fragrance, soothing effect.
Fatty acids	Oleic acid, palmitic acid	Emollient, moisturizing effect

Mechanism of action in Cosmetics

Anti-inflammatory Activity: The major components, α - and β -santalol, work to block inflammatory mediators, such as the production of prostaglandins and cytokines, causing the skin to appear less red and inflamed [3,24].

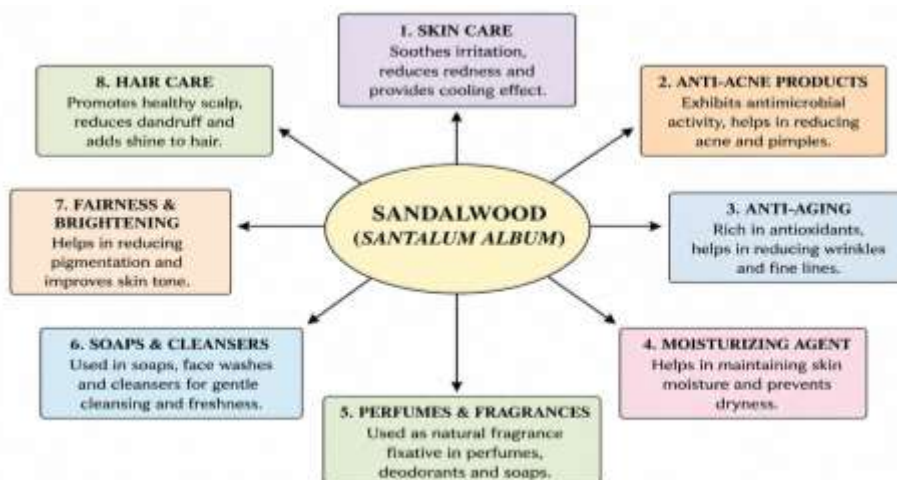
Anti-microbial Activity: Sandalwood possesses antibacterial and anti-fungal activity against *P. acnes* and another variety of skin pathogens, attributed to its antimicrobial activity, which can be beneficial in the treatment of acne [8,23].

Antioxidant Activity: Phenolic compounds found in sandalwood act to inhibit reactive oxygen

species, causing oxidative stress, stimulating the time of normal skin aging [4,37].
Skin Soothing and Cooling Properties: Sandalwood has a relaxing and cooling effect on the skin, with a particular effects on sensitive skin [7].

Inflammatory properties may indirectly promote collagen buildup by alleviating oxidative damage of cells[30].

Cosmetic applications of Sandalwood [7,34,37]



Formulation Aspects

Sandalwood face pack: Mixed with water or rose water to form a smooth paste, which provides an instant feeling of soothing and cooling to the skin. It has soothing, anti-inflammatory, anti-acne and anti-oily properties; and enhances the texture and tone of skin [2].

Sandalwood cream: Prepared as oil-in-water or water-in-oil type emulsions comprising sandalwood oil. These compositions improve the stability and skin penetration of active ingredients and have moisturizing and protective effects on skin [5].

Sandalwood gel/serum: Prepared using appropriate gelling agents or more specialized modern nano-

carriers like nano-particles. These systems show increased penetrability into the deeper layers of skin and sustained, controlled release of the active principles [28].

Advanced formulation: Using modern delivery systems e.g. liposomes, nanoemulsions, solid lipid nanoparticles etc. which improve bioavailability, stability, targeted delivery of sandalwood actives as well as increasing therapeutic efficiency [11,26].

Safety and Toxicity

Sandalwood is considered to be safe for topical use when used in suitable concentrations [9].

Concentrated essential oil if used in sensitive individuals may produce irritation or allergic reactions [10,34].

Proper formulation, patch testing, and dilution levels are needed to confirm its safety. Evaluation of long term safety and regulatory approval is required for its use as a cosmeceutical agent [6,33,18].

Advantages of Sandalwood in cosmetic applications

Natural and biodegradable: Sandal wood is a natural resource and is biodegradable or environmentally friendly compared to other chemical constituents. It imparts neat and green products [2,15,17].

Anti-inflammatory: The compound α -Santalol in sandal helps in reducing inflammation, redness and itching. It is therefore suitable for blemished, sensitive and irritated skin [3,13].

Anti-bacterial activity: The compounds in sandal are active against bacteria as well as various other microorganisms. This makes it efficient for preventing the formation of bacteria that lead to infections and pimples [8,27].

Aromatic properties: The natural scent of sandal is aromatic and remains for a longer period of time.

This property is incorporated in perfumes, creams and oils to give a fresh feel [6,11].

Activity against various uses: Sandal contributes to anti-aging, moisturizing, soothing and skin protecting activities. This reduces the number of ingredients used in a single product [20,30].

Limitations of Sandalwood in cosmetic applications:

Expensive: Sandalwood is very high-cost since it is slow-growing tree, taking many years to reach maturity and thus consequentially, affecting the final cosmetics' cost [6,19].

Adulteration: Due to high demand and the high-cost of sandalwood, some officials have listed the possibility of adulteration of the oil with synthetic substitutes or cheaper oils, thus diminishing the desired effect [9,38].

Stability: Since the constituents of the oil are susceptible to light, air and heat. Improper storage and formulation may result in a breakdown of the components [5,25].

Restricted production: Since sandalwood planting is tricky and requires a great deal of time, it is difficult to obtain large-scale industrial production.

is generally safe to use but very concentrated levels may cause allergy skin reaction or sensitivity in some people [26,32].

It may have harmful consequences at greater quantities, particularly when neem oil is present. As a result, it's critical to keep safe boundaries when formulating. [16,18,25].

Recent advances and future perspectives

Recent developments aim at improving delivery efficiency of sandalwood by utilizing novel technologies [4,36]. Topical application of nano-based delivery systems, such as liposomes, solid lipid nanoparticles and nanoemulsions, demonstrates better permeation through skin and sustained release of active constituents [28].



Biotechnological methods to enhance production as well as quality assurance of sandalwood oil are under investigation [32]. Synergistic formulations with other herbal active compounds also show promise for cosmetic benefits [33,40].

CONCLUSION

Sandalwood (*Santalum album*) is one of the most valuable and popular natural ingredients in cosmetics and cosmeceuticals as it possesses a broad spectrum of bioactivities like anti-inflammatory, antimicrobial, antioxidant, anti-oedema, anti-psoriatic and calming effects [3]. The various bioactivities of sandalwood and its formulations have made it more useful in the treatment of various skin problems such as acne, irritation and ageing. The wide compatibility with various skin types, particularly sensitive skin, of sandalwood has made it an essential constituent in recent cosmetics. The successful adaptation of products containing sandalwood with modern innovations like nanotechnology, liposomes, robust extraction methods and others has thereby furthered the stability, bioavailability and efficacy of the product [5]. The application of such innovations has opened up a realm of endless prospects of using sandalwood in high-class cosmetics and cosmeceuticals. Although there are some limitations like an expensive raw material base, limited availability, adulteration and false-testing; these are gradually being negated with recent developments on sustainable cultivation, application of new technologies and a deeper understanding of its efficacy. Due to this ongoing technological evolution, sandalwood has a promising future in the formulation of innovative and efficacious cosmetics. [28,40].

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