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The role of hemp (*Cannabis sativa* L.) in cosmeceuticals and personal care: A systematic review

Iqra Mushtaq[1], Khalid Hussain[1*], Khalid Nawaz[1], Rabia Amin[1], Shah Jahan Nasir[1], Abdul Wahab Malik[1], Noshia Arshad[1], Saima Bashir[1], Manal A. Alshaqhaa[2], Tehreem Riaz[1]

[1]Department of Botany, University of Gujrat, Gujrat, Pakistan
[2]Biology Department, College of Science, King Khalid University [KKU], Abha 61413, Saudi Arabia

Abstract
The hemp botanical resource has a wide scope of application in cosmeceutics and personal care. Hemp, rich in essential fatty acids, cannabinoids, cannabidiol (CBD), flavonoids, terpenoids, and antioxidants, possesses several therapeutic properties, including anti-inflammatory, antioxidant, sebo-regulatory, and photoprotective effects. This review exposes the history, phytochemistry, and mode of action of hemp in promoting dermatological applications. Priority attention is given to the combined application of hemp seed oil and CBD to promote bioavailability and skin penetration via emulsions, nanoemulsions, liposomes, and solid nanoparticles. The clinical tests apprise about the possibility of using hemp to cure acne, atopic dermatitis, psoriasis, alopecia, and oxidative skin damage. The regulatory environment, safety concerns, and its acceptability in the market have been a topic of discussion, and there is a need to standardize the cannabinoid content, mode of administration, and clinical evidence of clinical effectiveness. Due to the existing regulatory and formulation challenges, hemp-based cosmeceuticals stand at the core of personalized skincare and trichology due to the multifunctional nature of its bioactive compounds.

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Introduction

Hemp (*Cannabis sativa* L.), belonging to the Cannabaceae family (Mygdalia et al., 2025), is not well-known from its history, and there are no indications about its origin. However, the overwhelming majority of scientists believe that hemp probably originated from Eastern or Central Asia, although China can be considered as one of the most probable centers of early cultivation for medicinal properties (Nabil et al., 2024). From the 22nd century BC to the 16th century BC, hemp was introduced into most European regions (Russo, 2001). However, other evidence shows that it is indigenous to Europe too. Hemp has a history of production for fiber and textile purposes as well as animal feed, but its culture declined in the first half of the 20th century owing to legal implications (Dickson et al., 2019) related to psychotropic substance content (Harlow et al., 2022). Hemp resurfaced its cultivation towards the new millennium, first in Canada (McCann et al., 2023), followed by Europe and the United States, for which changes in laws were made to permit the crop

***CONTACT** Khalid Hussain, khalid.hussain@uog.edu.pk, Department of Botany, University of Gujrat, Gujrat, Pakistan

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to resume industrial usage again (Visković et al., 2023).

Hemp is also gaining attention for its bioactive constituents with antimicrobial, anti-inflammatory, and antioxidant properties in cosmetics (Žugić et al., 2024). Industrial hemp (*Cannabis sativa* L.) has sustainable uses in textiles, cosmetics, and bioplastics, with fibers highly valued for durability and biodegradability. Indian production is delayed by rough texture, poor spinnability, and machinery compatibility issues, requiring cottonization (Visković et al., 2023). Removing barriers in regulation and processing can make India a market leader in the international hemp industry (Kolkar et al., 2025). Industrial hemp is a low-THC crop that contains abundant non-psychoactive cannabinoids with strong anti-inflammatory, neuroprotective, and antioxidant activities. However, supercritical fluid extraction (SFE) and supercritical fluid chromatography (SFC) were found useful to effectively isolate, characterize, and evaluate cannabinoids from hemp for cosmetic uses, with high purity and stringent quality control (Papadopoulos et al., 2025).

Hemp is now valued more as a crop because of its unique agronomic characteristics and its ability to produce high-grade raw materials, like fiber and oil, that are appropriate for numerous industrial uses (Yano and Fu, 2023). Of its most viable applications, hemp-based construction materials, like hempcrete, have emerged as environmentally-friendly substitutes for traditional building materials (Tong and Memari, 2025). Hempcrete is especially suited for insulation, wall panels, and roofing with structural performance as well as environmental advantages (Small and Marcus, 2002; Amaducci, 2005; Tong and Memari, 2025). The use of green, plant-based hemp materials in building construction helps improve the carbon dioxide emission reduction rate, aligning with the recent aims of sustainable development and green building technologies (Muhit et al., 2024).

This review was undertaken to decipher the cosmeceutical and personal care uses of hemp because, in most cases, it is considered a weed that has no medicinal uses.

Phytochemical composition of hemp

Hemp has a peculiar and very wide phytochemical profile that contributes much to its dermatological and cosmeceutical potential. The plant has its main basis of synthesis of cannabinoids, terpenoids, flavonoids, and essential fatty acids, many of which have a pharmacologic effect on the human skin physiology (Mounessa et al., 2017). The well-known phytocannabinoid that has been extensively investigated is cannabidiol (CBD) with its non-psychoactive profile and neuron reactivity in the cutaneous endocannabinoid system affecting sebocytes, skin barrier functions, and anti-inflammation (Lopes, 2024).

The effects of cannabidiol (CBD), cannabigerol (CBG), and cannabinol (CBN) occur at the level of not only cannabinoid (CB1/CB2), but also transient receptor potential (TRP) channels on skin cells (Filipiuc et al., 2023). Such substances proved to have a beneficial effect in terms of controlling the keratinocyte multiplication and the ability to release inflammatory cytokines, which makes them relevant to acne, eczema, and atopic dermatitis treatment (Martins et al., 2022). Moreover, hemp seed oil has an excellent balance of omega-6 and omega-3 fatty acids (3:1), as well as a high level of linoleic acid and alpha-linoleic acid, which stimulate epidermal homeostasis and hydration of the skin (Pei et al., 2020).

Besides cannabinoids, hemp synthesizes more monoterpenes and sesquiterpenes like myrcene, caryophyllene, and limonene, which have antimicrobial and anti-inflammatory effects applicable in treating skin infections and oxidative stress (Eagleston et al., 2018). Cannflavin A and orientin are flavonoids, hemp-specific compounds; their strong antioxidants and UV protection properties make them contribute to the higher photoprotective efficacy of topical formulations (Jaruthiti, 2021). These bioactives have the synergetic effect called the entourage effect that enhances the therapeutic efficacy of cannabinoid-rich cosmeceuticals (Jairoun et al., 2021).

Compounds found in hemp as phytocannabinoids such as cannabidiol (CBD), cannabinol (CBN), cannabigerol (CBG), cannabichromene (CBC), and Δ^9-tetrahydrocannabinol (THC) (Fig. 1), have significant antioxidant activities, mainly because of their redox activity and ability to serve as lipophilic electron donors (Duczmal et al., 2024). CBD, specifically, is known to inhibit reactive oxygen species (ROS) generation in keratinocytes by activating the NRF2–heme oxygenase-1 (HO-1) pathway (Gęgotek et al., 2019). CBD also shows protective mechanisms against lipid peroxidation as well as increases in activity of the major cutaneous antioxidant enzymes, including superoxide dismutase (SOD) and glutathione peroxidase (GPx) (Jîtcă et al., 2023). CBD has also been found to have robust anti-inflammatory activity and is thus an interesting compound for the treatment of dermatological disorders like acne, atopic dermatitis, and psoriasis (Rusu et al., 2025). Its action involves inhibition of

NF-KB signaling by activation of IKK, which results in the downregulation of pro-inflammatory cascade pathways (Sheriff et al., 2020). These antioxidant and anti-inflammatory properties justify the increasing application of CBD in dermatology and cosmetic products in skin repair and prevention of inflammatory skin diseases.

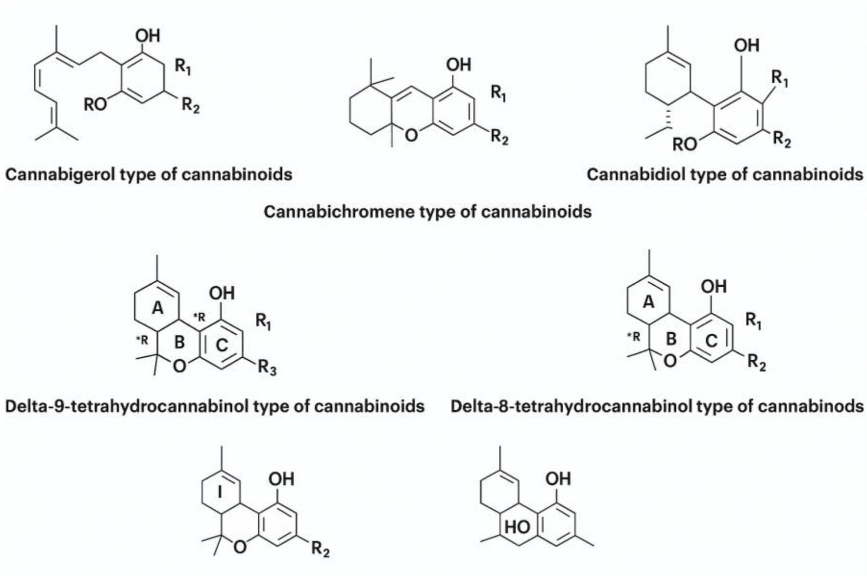

Fig.1: The main cannabinoids found in the hemp extracts

Hemp has recently become an object of public and regulatory controversy because of its close genetic affinity with high-THC (tetrahydrocannabinol) yielding strains of cannabis. THC, or Δ^9-tetrahydrocannabinol, is the major psychoactive chemical in charge of the mind-altering effects of marijuana (Bouloc, 2013) (Fig. 1). Although all types of hemp contain trace levels of THC, its level is substantially different from that of marijuana. Medicinal or recreational cannabis usually has a THC concentration between 10% and 30%, while industrial hemp is properly referred to as *Cannabis sativa* L. varieties with less than 0.2–0.3% THC, making it non-psychoactive (Sawler et al., 2015; Pacaphol and Aht-Ong, 2017; Żuk-Gołaszewska and Gołaszewski, 2018). However, industrial hemp with low THC content is often mistaken for a narcotic crop. In comparison, it is grown mostly for its high cannabidiol (CBD) content, which does not possess psychoactive features, but instead has many industrial and therapeutic uses.

Hemp oil has been used not only as a food item, but also in the production of cosmetics and personal care goods. These industries continue to be active, being commercially important, demonstrating the ongoing exploitation of hemp's multifunctional characteristics. Besides these historical applications, the industrial context of hemp materials and products is quickly changing with the new and novel uses across various market niches (Crini et al., 2020; Enarevba et al., 2024). Not only single active compounds from hemp but also its extracts and derivatives have been successfully introduced into different dermo-cosmetic products, especially emulsions. A methanol/water extract of dried hemp seeds at a level of 3% was introduced into a water-in-oil (W/O) cream stabilized with 2% Abil EM 90, which used 14% paraffin oil as a part of the oil phase (Ali et al., 2015).

Hemp seed oil

Both refined and unrefined hemp seed oils have been compounded as dispersed phases in stable oil-in-water (O/W) emulsions, using a blend of non-ionic emulsifiers sorbitan monooleate 85 and polysorbate 85 (Žugić et al., 2024). The maximum stability was realized using 10% surfactant concentration with an HLB value of 9 (Mikulcová et al., 2017). Additionally, the effect of process parameters like temperature, storage time, and light exposure on the oxidation of hemp oil in emulsions, namely those with an emulsifier based on soy lecithin, was examined (Raikos et al., 2015). Findings showed that hemp oil is extremely prone to oxidation in aqueous conditions, especially when subjected to light and high temperatures, and as such, antioxidants need to be added to the final product (Raikos et al., 2015).

Whereas emulsions are the most common type of dermocosmetics available, advanced nano-delivery systems have emerged to deliver improved efficacy and target delivery of active ingredients to the skin (Žugić et al., 2024). These include nanoemulsions, microemulsions, liposomes, vesicles, nanostructured lipid carriers (NLCs), and solid lipid nanoparticles (SLNs) (Ramanunny et al., 2021), among others.

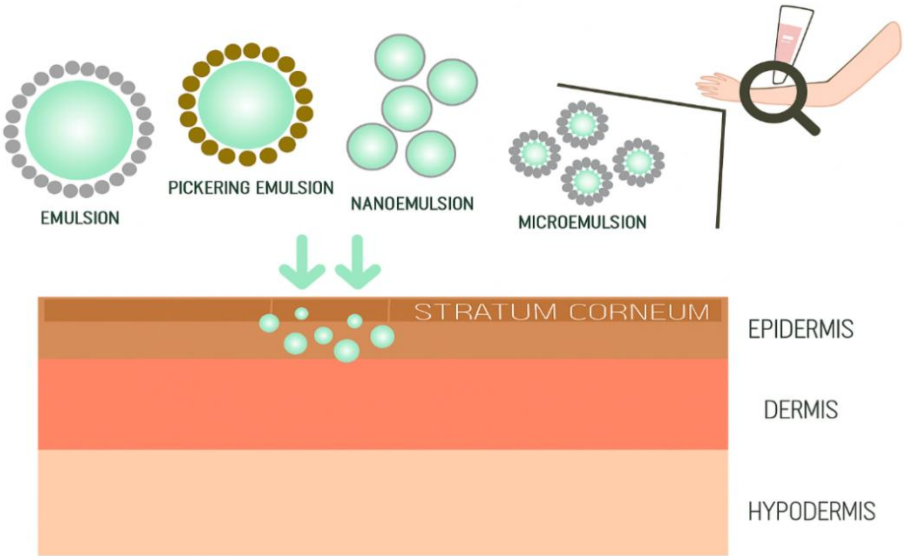

Fig. 2: Emulsion-based carriers for topical drug delivery

Skin care by hemp

To overcome the poor skin permeation characteristic of hemp oil-based systems, researchers have formulated nanoemulsions and microparticles of hemp seed oil (Lubart et al., 2023) (Fig. 2). A major challenge in the formulation of nanoemulsions, however, is minimizing not only the active material of hemp seed oil, but also the emulsifier to nanosized dimensions. By this nanosizing, enhanced skin penetration may be achieved, but at the same time, the risk of irritating the skin may be heightened (Seweryn et al., 2018). In another strategy, Lubart et al. (2023) were able to micronize hemp without surfactants and blend it into a cream, which was found to have significant antioxidant and anti-inflammatory activities. In addition, cannabidiol (CBD) has been successfully encapsulated in stable oil-in-water nanoemulsions and loaded into nanoemulsion-loaded chitosan hydrogels, with improved delivery and stability (Demisli et al., 2023).

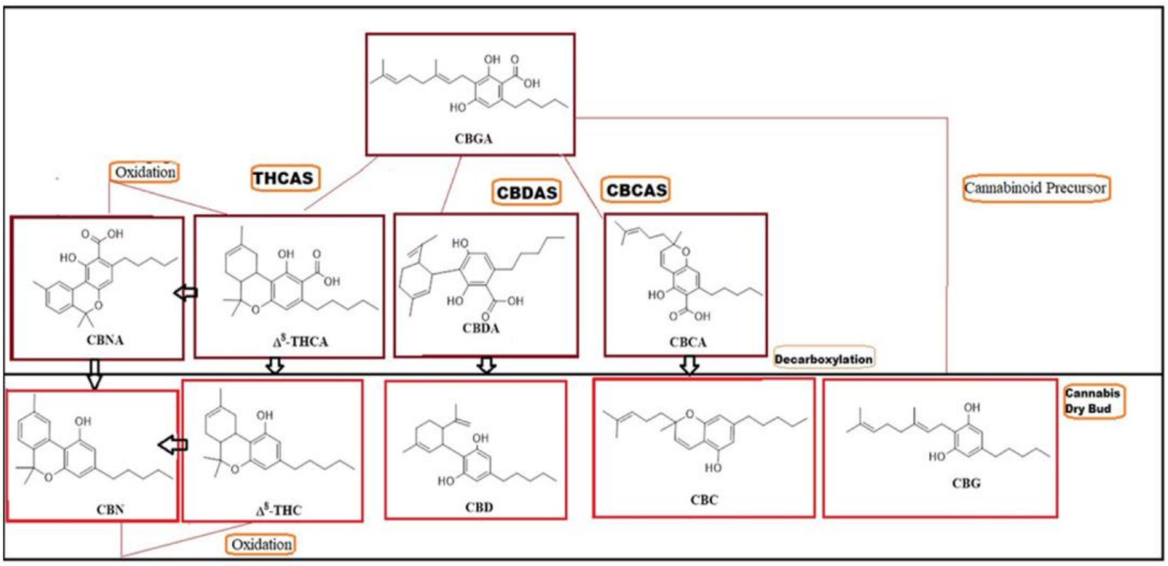

Fig. 3: Organization of significant elements of medicinal *Cannabis*

Preparation methods of cosmeceutical formulations

The efficiency, purity, and safety of hemp-derived cosmeceutical formulations strongly depend on the methods of extraction of the bioactive compounds (Fig. 3). Supercritical carbon dioxide (SC-CO_2) extraction is also considered one of the most appropriate methods due to its characteristic of extracting cannabinoids and terpenoids without causing thermal losses or leaving a trace of solvents (Boumghar, 2023). It exploits CO_2 beyond its critical point temperature and pressure, resulting in a combination of both a gas and a liquid capable of efficient extraction of non-polar molecules like cannabidiol (CBD) and low levels of oxidation (Rantaša et al., 2024). On the other hand, cold-pressing, widely applied to hemp seed oil, is a mechanical process that keeps thermolabile constituents, such as polyunsaturated fatty acids, tocopherols, and phytosterols, essential for skin hydration and repair (Pei et al., 2020). Nevertheless, such a technique has limitations because cannabinoids present in the glandular trichomes of the aerial parts of the plant cannot be extracted, and this approach is not enough to produce full-spectrum products (Martins et al., 2022).

Ultrasound-assisted extraction (UAE) has become a popular alternative to employing a green, bio-based alternative that enhances the yield and selectivity of cannabinoids and phenolic compounds due to the occurrence of acoustic cavitation, low solvent consumption, and decreasing the time of the extraction (Filipiuc et al., 2023). This renders it economical and sustainable for industrial-level operation. The extraction with ethanol is still used, however, with the high polarity and the Generally Recognized As Safe (GRAS) status, ethanol extraction requires at least two follow-up steps, namely, winterization and distillation to remove chlorophyll and waxes (Eagleston et al., 2018).

The choice of the extraction method should be relevant to the targeted formulation requirements, taking into account the intended bioactive concentration, compound stability, regulatory, and dermatological use (Jairoun et al., 2021). The selected approach is directly related to the therapeutic efficiency and safety mark of the resulting cosmeceutical, particularly when focusing on retention of a wide array of synergistic phytochemicals (Boumghar, 2023).

Mechanisms of hemp-derived substances' action in hair and skin care

Hemp-derived substances offer the greatest cosmeceutical potential by interacting with the cutaneous endocannabinoid system (ECS), which has a crucial role in skin homeostasis, skin barrier, and immune regulation (Mounessa et al., 2017). Cannabidiol (CBD) is reported to interact with transient receptor potential (TRP) channels, mainly indicating transient receptor potential vanilloid 1 (TRPV1) and transient receptor potential ankyrin 1 (TRPA1) that are found in keratinocytes and sebocytes, thereby causing the suppression of pro-inflammatory signaling molecules, including Interleukin-6 (IL-6) and Tumor Necrosis Factor alpha (TNF-alpha) (Oláh et al., 2014; Etemad et al., 2022). At the same time, cannabidiol (CBD) displays an inverse agonist of Cannabinoid Receptor 2 (CB2) that indirectly affects the synthesis of chemokines and reactive oxygen species in skin cells, providing it with anti-inflammatory and anti-oxidative properties essential in the treatment of acne, psoriasis, and eczema (Scheau et al., 2020).

Cannabidiol (CBD) also reduces the activity of the fatty acid amide hydrolase (FAAH) that delays the degradation of anandamide, an essential endogenous cannabinoid that activates proliferation and differentiation in skin cells (Toth et al., 2019). This process controls the work of sebaceous glands, decreasing hyperseborrhea associated with acne vulgaris (Jaruthiti, 2021). They are also associated with hemp terpenoids, which promote skin barrier activity and minimize transepidermal water loss, such as 8-caryophyllene, which has selective Cannabinoid Receptor 2 (CB2) agonistic effects, but additionally exerts synergistic action with cannabinoids (Filipiuc et al., 2023).

Regarding hair care, cannabidiol (CBD) and related phytocannabinoids have also demonstrated the modulation of hair cycle through the influence of Cannabinoid Receptor 1(CB1) and Transient Receptor Potential Vanilloid 4 (TRPV4) receptors in dermal papilla cells (Wal and Wal, 2024). Such receptors influence Wnt/β-catenin signaling, which plays an essential role in the hair growth (anagen) phase (Tijani et al., 2021). In addition, topical cannabidiol (CBD) was shown to regulate the differentiation of follicular keratinocytes and limit the inflammation of skin structures around the hair follicles, meaning that it can have potential in diseases like telogen effluvium and alopecia areata (Filipiuc et al., 2023). They are further exacerbated in cases where full-spectrum extracts are deployed, so that many signaling pathways can be regulated concurrently (Mounessa et al., 2017).

The photoaging-reducing effects caused by hemp extract can also be explained by antioxidative properties that pertain to the scavenging of photo-generated free radicals by cannabinoids and their increase in expression of Nrf2-regulated cytoprotective gene products, such as Heme Oxygenase-1(HO-1) and NAD(P)H: quinone oxidoreductase 1 (NQO1) (Toth et al. 2019). This is a biochemical protective mechanism that strengthens the elasticity of the skin and reduces collagen degradation, providing a biological explanation why the hemp active ingredients should be used in anti-aging skincare (Jokić et al., 2022). The synergistic action of hemp derivatives on inflammation, sebum control, oxidative stress, and hair cycle regeneration makes these substances highly multifunctional in dermatology and trichology (Pei et al., 2020).

Trends in the use of cosmeceutical and personal care products

The diverse bioactivities make the hemp-derived compounds diverse incorporations in a broad range of topical formulations. Hemp seed oil contains a perfect proportion of omega-6 and omega-3 fatty acids (3:1), vital in the reestablishment of the lipid bilayer and augmentation of transepidermal water retention, mainly in dry or atopic skin disorders (Pei et al., 2020). Concurrently, CBD-containing emulsions have anti-inflammatory and sebo-modulatory properties, which could be a viable addition to the skincare regimens of people with acne-susceptible or sensitive skin types (Jaruthiti, 2021), particularly when introducing them in nanoemulsified or liposome-like systems to achieve a better cutaneous penetration (Tijani et al., 2021).

Cannabinoids have a major role in the anti-aging and antioxidant skin care products in that they regulate the markers of oxidative stress and inhibit collagen breakdown (Kuzumu et al., 2024). It has been demonstrated that cannabidiol (CBD) increases Nrf2-driven antioxidant genes and inhibits the expression of matrix metalloproteinases (MMPs), which in turn can prevent photoaging and wrinkle development (Atalay Ekiner et al., 2022). These effects are especially topical when working with formulas that are used in the area of periorbital or perioral skin, where dermal suppression is reduced, and the process of collagen breakdown begins earlier (Filipiuc et al., 2023). Further, the incorporation of terpenoids (i.e., limonene and linalool) into the ROS scavenging helps increase the overall therapeutic index of these formulations (Jokić et al., 2022).

Cannabidiol (CBD) and cannabigerol (CBG) can play the role of care products on the scalp and hair due to their ability to mitigate follicular inflammation and improve the activity of the anagen phase (Wal and Wal, 2024). It is indicated that topical cannabidiol (CBD) receptor Cannabinoid Receptor 1/Transient Receptor Potential Vanilloid 4 at the dermal papilla cells modulates follicular regeneration signaling by upregulating Wnt/beta-catenin signaling (Tijani et al., 2021). Moreover, hemp seed oil is a lipidic delivery system that has high ceramide precursors and helps to repair scalp barriers, which leads to fewer episodes of seborrheic dermatitis (Pei et al., 2020). Such advantages are finding their way into shampoos and scalp serums and even anti-dandruff formulae intended to treat inflammatory alopecias (Filipiuc et al., 2023).

Cannabidiol (CBD) and hemp oil hold dual action in wound-healing and lip care by suppressing anti-inflammatory cytokines and promoting angiogenesis, which contributes greatly to epidermal regeneration (Mounessa et al., 2017). Its overall beneficial properties are reflected in the fact that full-spectrum extracts of hemp have been proven to enhance the reepithelialization process in minor abrasions and irritations, especially when applied topically in combination with occlusive substances such as beeswax or shea butter (Jaruthiti, 2021). Moreover, they are shown to have antimicrobial properties against skin pathogens on the skin (e.g., *Staphylococcus aureus*), expanding the domain of use in cases of infection-prone or damaged skin (Jokić et al., 2022).

Clinical and dermatological evidence

Restricted clinical and dermatological studies are acting to reinforce the therapeutic applicability of compounds of hemp to dermatology, particularly cannabidiol (CBD). The randomized, placebo-controlled, comparative study that involved 60 participants with mild to moderate atopic dermatitis revealed that the use of a topical 1% CBD cream leads to a significant reduction in Scoring Atopic Dermatitis (SCORAD) scores during the 8-week study period compared to placebo, signaling increased skin hydration and alleviated pruritus (Scheau et al., 2020). Moreover, decreased expression of inflammatory cytokines, such as Interleukin-31 (IL-31) and Interleukin-8 (IL-8), was revealed by skin biopsies, which substantiates molecular changes (Tóth, 2019).

An individual pilot trial on acne revealed that the excretion rate of sebum (SER) and erythema index under the topical cannabidiol (CBD) treatment over 12 weeks significantly reduced without adverse reactions, which was associated with Cannabinoid Receptor 2 (CB2) receptor involvement in the suppression of lipogenesis in sebocytes (Oláh et al., 2014). It is in line with the outcomes of non-invasive imaging that revealed decreased follicular plugging and elevated smoothness of the skin following the treatment, versus the quantification of such changes using 3D profilometry (Jokić et al., 2022). These results confirm the sebostatic and anti-inflammatory potential of hemp actives in the care of acne, which supports their cosmeceutical inclusion.

In addition to the skin conditions, trichological research has looked at how cannabinoids regulate the hair cycle. In a clinical trial of 35 subjects studied with a topical cannabidiol 3% formulation on alopecia areata, the observed improvement in hair density (mean of 31 hairs/cm 2) was observed after 6 months (Martinelli et al., 2022). The analysis using follicles proved a smaller anagen-to-telogen ratio and increased vascularization of the perifollicular area. Topical cannabinoid delivery systems were found to be safe and well-tolerated, as there was no irritation of the scalp and absorbed tetrahydrocannabinol (THC) systemically (Wal and Wal, 2024). All these clinical outcomes point to the fact that hemp-based formulations are effective and that they are well-tolerated with proven results in inflammatory dermatoses, seborrhea, and hair diseases. Nevertheless, the uniformity of content of extract, delivery device, and study protocols should be achieved to perform a repeatable study and obtain regulatory approval (Mazzara et al., 2022; Žugić et al., 2024).

Market acceptance, safety, and regulation

Hemp-derived ingredient introduction in cosmeceuticals requires critical safety assessment owing to the inherent inconsistency in the content of cannabinoids, extraction techniques, as well as dermal exposure. Isolated and purified cannabidiol (CBD) to cosmetic grade level was considered not to irritate or sensitize in several *in vivo* and *in vitro* dermal toxicity tests (Scheau et al., 2020). The finding was a complete skin safety profile established in 3% cannabidiol topical formulations in a 28-day repeat-insult patch test in human volunteers without any dermatological event involvement (Martinelli et al., 2022). Additionally, the systemic absorption of topical cannabinoids is insignificant in the case of tetrahydrocannabinol (THC) below the maximum legal threshold, and no psychotropic effects are an issue (Baral et al., 2020).

The safety of the product, however, is determined strongly by extract purity and is free of contaminants like residual solvents, pesticides, or heavy metals, particularly full-spectrum hemp extracts (Jokić et al., 2022). In Europe, the use of purified cannabidiol (CBD) has been approved by regulatory agencies such as the European Commission (EU CosIng database), although the use of extracts of uncontrolled sources of cannabis is still restricted (Tóth, 2019). At the present moment, the Food and Drug Administration (FDA) has not released a formal monograph of cannabidiol (CBD) in cosmetics, but has allowed its addition when not branded as a therapeutic product and limited amounts of less than 0.3% tetrahydrocannabinol (THC) as per the 2018 Farm Bill (Atalay et al., 2019).

The regulatory acceptance also differs greatly all around the world. In Canada, hemp seed oil is simply legalized in personal care products, whereas cannabinoids, including cannabidiol (CBD), must receive the Natural Product Number (NPN) issued by Health Canada to make any claims beyond moisturization (Wal and Wal, 2024). In the meantime, Asia-Pacific marketplaces, especially Japan and South Korea, have authorized the cannabidiol in topical cosmetics in zero-tetrahydrocannabinol legalizations, setting the need to have oriented the isolate-based elaborations, especially in light of the new regulatory position in these Asia-Pacific markets with a requirement of 0-tetrahydrocannabinol (Žugić et al., 2024). Such regional differences present problems to international brand compliance and Good Manufacturing Practices (GMP) agreement (Mazzara et al., 2022).

On market acceptance terms, hemp cosmeceuticals have witnessed explosive growth, particularly in North America and Europe. As per the recent analysis in the industry, the hemp cosmetics industry was valued at more than USD 5.5 billion in 2023, and this growth can be attributed to the rising preference of consumers towards multifunctional, clean-label, anti-inflammatory skincare products (Jokić et al., 2022). Although the number of products has increased, dermatologists and consumers continue to be concerned when it comes to standardization, clinical efficacy, and labeling concerns, which tend to vary depending on the inconsistency in regulation (Martinelli et al., 2022). Thus, brands must focus on open cannabinoid profiling, batch testing, and claim validation to adhere to consumer trust and regulatory compliance (Scheau et al., 2020; Limbacher et al., 2025).

Conclusion

Regardless of the increasing demand for hemp-based cosmeceuticals, formulation science requires critical standards regarding standardization. There is a lack of consistent concentrations of key actives presented in different phytochemical compositions between hemp cultivars, which are influenced by genotype, agricultural techniques, and production technology. This makes the reproducibility of therapeutic deposition even more problematic because many cannabinoids are absent in most cosmetics in a unified protocol of quantification, except in cases where the full-spectrum extracts or broad-spectrum extracts are used (Zugic et al., 2024). Besides, ineffective phytochemical fingerprinting characterizes numerous commercial products, and such an aspect threatens the product performance and approval. Another challenge is the optimization of the delivery systems, as the cannabinoids have a high lipophilic property and have difficulty penetrating the stratum corneum. Traditional formulas have the issues of low bioavailability and inability to penetrate the skin effectively, so they cannot provide all the possibilities of the actives in dermal and follicular targets (Atalay et al., 2019). Newer forms of delivery like nanoemulsions and solid lipid nanoparticles, and ethosomes are in the research pipeline and promise to bring with them greater stability, penetration, and timed release of cannabidiol (CBD) and other phytocompounds (Jokić et al., 2022). Nonetheless, these nanocarriers have to be thoroughly reviewed in terms of toxicity and government approval before they can be applied commercially on a large scale. The lack of predictability in regulations is still an obstacle to international harmonization and scale in the market. Whereas jurisdictions allow using cannabidiol (CBD) in topical formulations (under a set of purity limits), in others, cannabis is considered a narcotic drug, making interstate distribution cumbersome and labelling problematic (Scheau et al., 2020). Moreover, there are no cosmetic-specific monographs of cannabinoids in a number of pharmacopeias, which creates a vacuum in the classification of products, test methods, and the shelf-life declaration of products (Zugic et al., 2024). These discrepancies create disproportion on the side of manufacturers to align with the multinational regulatory mechanisms and, in most cases, slow product introductions/release and constriction of the innovation pipeline (Wal and Wal, 2024).

Prospects

In the future, there will be a need for clinical evidence generation and studies of a mechanistic nature to support cosmeceutical claims. Although preclinical results are encouraging, few human dermatology studies have been performed; most trials to date are double-blind, placebo-controlled (Tóth et al., 2019). Besides, the long-term consequences of frequent cannabinoid usage, including desensitization of the receptor or changes in the condition of skin microbiota, remain unexplained. The focus in the future should be on determining what the ideal ratios of cannabinoids are, their reasonable level of usage, and biomarker-based endpoints of efficacy that will allow the creation of specifically targeted formulations with scientifically supported evidence. In a nutshell, hemp has recovered its status as a multi-functional crop of global value in cosmeceutical and personal care markets. Its bioactive molecules, such as hemp seed oil and cannabidiol, are rich in antioxidants, anti-inflammatory components, and skin-nutrition benefits. The discovery of new nano-delivery systems holds further promise, with its accelerating use in novel dermatological formulations.

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Ethical approval

This study does not involve human/animal subjects, and thus no ethical approval is required.

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No supplementary material is included with this manuscript.

Conflict of interest

The authors declare no conflict of interest.

Availability of primary data and materials

As per editorial policy, experimental materials, primary data, or software codes are not submitted to the publisher/Journal management. These are available with the corresponding author (s) and/or with other author(s) as declared by the corresponding author (s) of this manuscript.

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