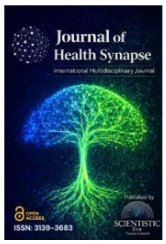
Research Article **ISSN: 3139-3683**

JOURNAL OF HEALTH SYNAPSE (JHS)
Peer Reviewed Refereed Open Access International Multidisciplinary Journal
Publisher: *Scientistic Era Private Limited*
Journal Hompage: *https://healthsynapse.org*



A Review on Transdermal Formulations for Enhanced Cutaneous Delivery of Sea Buckthorn and Botanical Anti-Aging Bioactives

Kesharwani Vineet[a], Rathore Abhimanyu Singh[a*], Chhajed Mahavir[a]

[a]*Department of Pharmaceutics, Oxford International College, Indore, Madhya Pradesh, India*

***Corresponding author:** rathorejodha96@gmail.com

This is an open-access article distributed under the terms of the Creative Commons Attribution 4.0 International License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) and the source are properly cited.

ARTICLE INFO

KEYWORDS:
Skin aging; Sea buckthorn (Hippophae rhamnoides); Botanical bioactives; Transdermal drug delivery; Nanocarriers; Liposomes; Nanoemulsion; Skin permeation; Quality by Design (QbD).

ARTICLE HISTORY
Received Date: 30 September 2026
Revised Date: 15 October 2026
Accepted Date: 30 October 2026
Published Date: 15 November 2026

CITATION
Singh, R. A., A Review on Transdermal Formulations for Enhanced Cutaneous Delivery of Sea Buckthorn and Botanical Anti-Aging Bioactives, *Journal of Health Synapse (JHS), 1(4), 129-138.*
https://doi.org/10.67529/jhs.v1i4.10

A B S T R A C T

Skin aging is a complex, progressive biological process driven by intrinsic chronological senescence and extrinsic environmental stressors—most notably ultraviolet (UV) radiation, airborne particulate pollutants, and reactive oxygen species (ROS)—resulting in collagen fragmentation, elastin degradation, epidermal dehydration, dyspigmentation, and wrinkle formation. Botanical bioactive compounds derived from sea buckthorn (Hippophae rhamnoides) and complementary medicinal plants, including carotenoids, tocopherols, polyphenols, flavonoids, green tea catechins, curcumin, resveratrol, and Centella asiatica triterpenoids, demonstrate potent antioxidant, anti-inflammatory, photoprotective, and matrix metalloproteinase (MMP)-modulating properties. However, their dermatological efficacy is frequently restricted by poor aqueous solubility, chemical and photolytic instability, batch-to-batch phytochemical variability, and limited permeation across the stratum corneum. Advanced transdermal and topical drug delivery platforms—encompassing permeation-enhanced hydrogels, emulgels, liposomes, transfersomes, ethosomes, nanoemulsions, solid lipid nanoparticles (SLNs), nanostructured lipid carriers (NLCs), and polymeric matrix films—offer effective strategies to protect labile phytoconstituents and enhance localized epidermal and dermal deposition. This review examines the molecular mechanisms of botanical anti-aging agents, cutaneous barrier challenges, rational vehicle and nanocarrier design, physicochemical and rheological characterization, Franz diffusion permeation kinetics, biocompatibility and clinical bioengineering evaluation, Quality by Design (QbD) optimization, and Indian and international regulatory frameworks.

1. Introduction

Human skin undergoes continuous structural, biochemical, and physiological remodeling across the lifespan [1]. Skin aging is a progressive biological phenomenon governed by two overlapping mechanisms: intrinsic (chronological) aging, driven by genetic programming, hormonal decline, and cellular senescence, and extrinsic aging (photoaging), accelerated by chronic exposure to solar ultraviolet (UV) radiation, airborne particulate pollutants, tobacco smoke, and environmental pro-oxidants [1–3]. Clinically, aged skin presents with xerosis, fine lines, deep rhytides, loss of viscoelasticity, uneven dyspigmentation, and rough surface microrelief, reflecting impaired epidermal turnover and fragmentation of the dermal extracellular matrix [3,18,19].

Oxidative stress plays a central pathogenic role in premature skin aging [2,19]. Reactive oxygen species (ROS) generated by UV irradiation and environmental pollutants inflict oxidative damage on cellular lipids, proteins, and genomic DNA, while activating mitogen-activated protein kinase

(MAPK) signaling cascades and transcription factors such as activator protein-1 (AP-1) and nuclear factor-kappa B (NF-κB) [2,3]. This transcriptional activation upregulates matrix metalloproteinases (MMP-1, MMP-3, and MMP-9), accelerating the proteolytic cleavage of dermal Type I and Type III collagen and elastin fibers [19]. Concurrently, age-associated depletion of stratum corneum ceramides and natural moisturizing factors impairs epidermal barrier function, increasing transepidermal water loss (TEWL) and susceptibility to irritation [4].

Botanical bioactive compounds—particularly carotenoids, tocopherols, flavonoids, polyphenols, and triterpenoids derived from sea buckthorn (Hippophae rhamnoides) and complementary medicinal plants—have gained prominence in pharmaceutical and cosmeceutical research owing to their antioxidant, anti-inflammatory, photoprotective, and collagen-preserving properties [5,6,20–24]. Nevertheless, conventional topical creams and lotions frequently fail to deliver therapeutic concentrations into target skin layers due to poor aqueous solubility, rapid oxidative or photolytic degradation, and restricted stratum corneum permeability [7–9]. Advanced transdermal and topical delivery systems—including permeation enhancers, liposomes, transfersomes, ethosomes, nanoemulsions, solid lipid nanoparticles (SLNs), nanostructured lipid carriers (NLCs), and polymeric matrix films—offer rational strategies to enhance stability, cutaneous retention, and controlled release [7–12,25–28].

2. Background and Formulation Rationale

The dermatological effectiveness of a botanical anti-aging agent depends not only on its intrinsic pharmacological potency but also on its ability to reach and persist within the target cutaneous compartment [5,7]. The stratum corneum, forming the outermost layer of the epidermis, constitutes the primary physicochemical barrier to percutaneous absorption, consisting of keratin-enriched corneocytes embedded within a continuous, multilamellar intercellular lipid matrix of ceramides, cholesterol, and free fatty acids [4,29,30]. This tightly organized structure restricts passive transport of both hydrophilic molecules and high-molecular-weight polyphenolic compounds.

Furthermore, botanical extracts often comprise complex mixtures of secondary metabolites with diverse molecular weights, polarities, and solubility profiles, complicating uniform formulation and reproducible quality control [5,6]. Major limitations hindering botanical anti-aging formulations include poor aqueous solubility, susceptibility to light/oxygen/pH-induced degradation, low stratum corneum diffusivity, inadequate epidermal and dermal retention, seasonal batch-to-batch phytochemical variability, and potential excipient- or extract-induced sensitization [8,9]. Crucially, for topical anti-aging formulations, localized depot retention within the viable epidermis and upper dermis is far more desirable than extensive systemic transdermal absorption [16,18].

3. Botanical Anti-Aging Actives and Mechanisms of Action

3.1. Major Classes of Botanical Anti-Aging Actives

Phytochemicals isolated from fruits, seeds, leaves, roots, and bark counteract skin aging through complementary molecular pathways [5, 6]. Key candidate actives include:

- **Sea Buckthorn (Hippophae rhamnoides) Bioactives:** Seed and pulp oils/extracts are exceptionally rich in carotenoids (β-carotene, lycopene, zeaxanthin), tocopherols, tocotrienols, flavonols (isorhamnetin, quercetin), and rare omega-7 (palmitoleic) and omega-3/-6 fatty acids that replenish barrier lipids, suppress UV-induced lipid peroxidation, and accelerate dermal repair [20–24].
- **Resveratrol:** A stilbenoid polyphenol abundant in grapes (Vitis vinifera) and berries that scavenges ROS, activates sirtuin longevity pathways, and attenuates UV-mediated AP-1 and MMP-1 expression, though constrained by low water solubility and photoisomerization [5,33,34].
- **Green Tea Catechins (EGCG):** Epigallocatechin gallate from Camellia sinensis exhibits potent radical-scavenging and photoprotective activity, mitigating UVB-induced erythema, DNA damage, and collagen degradation [5,35,36].
- **Curcumin:** A diarylheptanoid polyphenol from Curcuma longa rhizomes possessing strong NF-κB and COX-2 inhibitory activity, limited by poor aqueous solubility, photosensitivity, and alkaline hydrolysis [6,40].
- **Centella asiatica Triterpenoids:** Asiaticoside, madecassoside, asiatic acid, and madecassic acid stimulate fibroblast proliferation, Type I collagen synthesis, and epidermal barrier restoration [5,37,38].
- **Pomegranate Polyphenols:** Punicalagins, ellagitannins, and anthocyanins provide robust antioxidant defense against photo-oxidative stress and extracellular matrix breakdown [5,39].

3.2. Molecular Mechanisms of Cutaneous Anti-Aging Activity

As illustrated in Figure 1, botanical bioactives delivered via advanced carriers exert multi-target dermatological benefits through: (i) direct neutralization of UV- and pollution-induced ROS; (ii) downregulation of pro-inflammatory cytokines (TNF-α, IL-1β, IL-6) and COX-2; (iii) inhibition of collagenolytic MMP-1, MMP-3, and MMP-9 enzymes alongside stimulation of procollagen synthesis; (iv) attenuation of UV-induced cellular apoptosis; and (v) restoration of stratum corneum hydration and intercellular ceramide architecture [2–6,24,36].

Figure 1. Molecular and Cutaneous Anti-Aging Mechanisms of Sea Buckthorn and Botanical Bioactives via Transdermal Nanocarriers

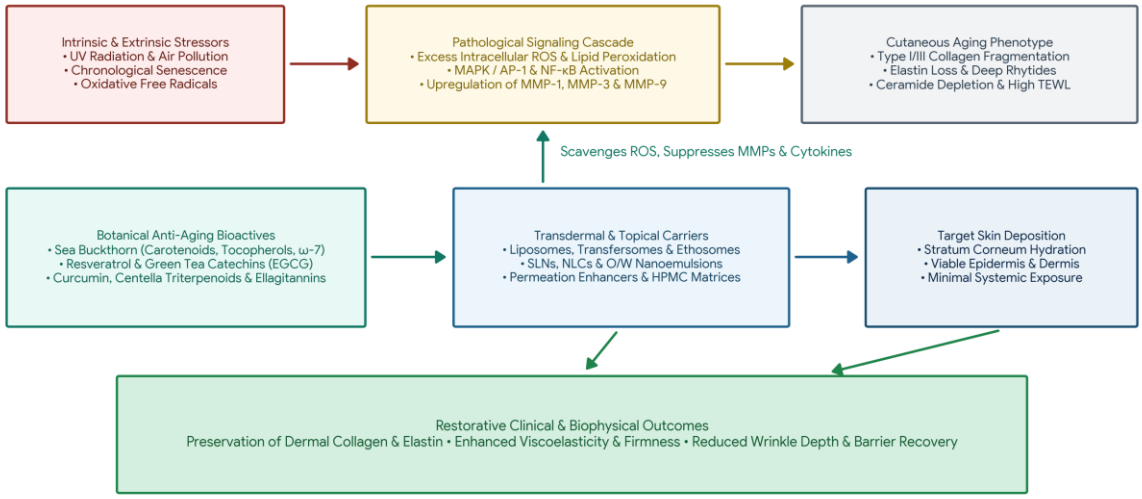


Figure 1. *Proposed molecular and cutaneous anti-aging mechanisms of sea buckthorn and botanical bioactives delivered via transdermal nanocarriers.*

4. Cutaneous Permeation Pathways and Delivery Challenges

Human skin comprises three principal anatomical layers: the avascular stratified epidermis (including the rate-limiting stratum corneum), the vascularized collagen- and elastin-rich dermis housing fibroblasts, and the subcutaneous adipose hypodermis [1,7]. Permeant molecules traverse the stratum corneum via three primary routes: (1) the tortuous intercellular lipid pathway between corneocytes; (2) the transcellular pathway directly across hydrated corneocytes and surrounding lipid lamellae; and (3) the appendageal shunt pathway through hair follicles and sweat glands [7,29,30].

As summarized in Table 1, overcoming the physicochemical and biopharmaceutical barriers of botanical anti-aging actives requires aligning each formulation limitation with a targeted pharmaceutical carrier or excipient strategy [8–12,25–28].

Table 1. Major Physicochemical and Biopharmaceutical Challenges in Botanical Skin Delivery and Formulation Solutions

Delivery Challenge	Underlying Mechanism	Formulation-Related Solution
Poor Aqueous Solubility	High crystallinity and lipophilicity of carotenoids, polyphenols, and triterpenoids	Cosolvents, O/W nanoemulsions, SLNs, NLCs, and phospholipid vesicles
Chemical & Photo-Instability	Oxidation, hydrolysis, and photolysis of conjugated phenolic rings under light/air	Lipid-core encapsulation, chelating antioxidants, and UV-opaque airless packaging
Low Stratum Corneum Permeability	Tightly packed corneocytes embedded in intercellular ceramide-cholesterol lamellae	Chemical/herbal permeation enhancers (oleic acid, terpenes), ethosomes, and transfersomes
Rapid Surface Loss & Wash-Off	Low substantivity and short residence time of conventional aqueous lotions	Bioadhesive polymeric matrices (HPMC, Carbopol, PVA) and film-forming systems
Batch-to-Batch Extract Variability	Seasonal, geographical, and harvesting fluctuations in plant secondary metabolites	Botanical authentication, HPTLC fingerprinting, and HPLC marker standardization
Cutaneous Irritation & Sensitization	Excessive surfactant levels or minor allergenic phytoconstituents disrupting barrier lipids	Excipient compatibility screening, MTT viability, and OECD 439 RhE irritation testing

5. Rational Formulation Design and Carrier Technologies

5.1. Vehicle Selection

The topical vehicle governs active solubilization, thermodynamic activity, skin hydration, and release kinetics [7,18]. As detailed in Table 2, vehicle selection is guided by the lipophilicity (log P) of the sea buckthorn or botanical active, target skin-layer deposition, and patient sensory acceptability.

Table 2. Comparative Characteristics and Dermatological Applications of Topical and Transdermal Vehicles

Hydrogel	Three-dimensional water-swollen hydrophilic polymer network; non-greasy and cooling	Water-soluble phenolic acids, green tea EGCG, and glycosidic extracts
Oleogel	Structured anhydrous lipid matrix formed by organogelators; occlusive barrier support	Highly lipophilic sea buckthorn carotenoids, tocopherols, and phytosterols
Emulgel	Biphasic emulsion immobilized within an aqueous hydrogel matrix; dual-solubility capacity	Complex botanical extracts containing both hydrophilic and lipophilic bioactives
Semisolid Cream	Oil-in-water or water-in-oil multiphase emulsion with emollient fatty alcohols	Daily barrier moisturization and sustained epidermal anti-aging care
Nanoemulsion	Kinetically stable submicron (20–200 nm) colloidal dispersion with high interfacial area	Poorly water-soluble polyphenols (resveratrol, curcumin) requiring enhanced deposition
Hydroalcoholic Gel	Aqueous-ethanolic polymer base facilitating rapid solvent evaporation and partitioning	Moderately lipophilic flavonoids requiring enhanced stratum corneum partitioning

5.2. Chemical and Herbal Permeation Enhancers

Permeation enhancers transiently reduce stratum corneum barrier resistance by fluidizing intercellular lipid bilayers, interacting with intracellular keratin domains, or increasing active partitioning into the skin [8,9,11,12]. Widely investigated enhancers include oleic acid, propylene glycol, ethanol, isopropyl myristate, Transcutol P, lauric acid, and natural terpenes (e.g., menthol, limonene, 1,8-cineole) [11,12]. Their concentrations must be carefully optimized to enhance dermal flux without causing erythema or irreversible barrier disruption [14].

5.3. Advanced Vesicular and Lipid Nanocarrier Systems

Nanocarriers improve the solubilization, photostability, and cutaneous localization of botanical actives [25–28,33,34,52]:

- **Liposomes:** Spherical phospholipid bilayer vesicles capable of encapsulating hydrophilic bioactives within their aqueous core and lipophilic actives within the lipid bilayer [29].
- **Transfersomes:** Ultra-deformable vesicles composed of phospholipids and edge activators (e.g., sodium cholate, Tween 80) that squeeze through narrow intercellular pathways under transdermal hydration gradients [25].
- **Ethosomes:** Phospholipid vesicles incorporating high ethanol concentrations (20–45% w/v), fluidizing both vesicular bilayers and stratum corneum lipids to promote deeper cutaneous deposition [26].
- **Solid Lipid Nanoparticles (SLNs) and Nanostructured Lipid Carriers (NLCs):** Submicron lipid matrices that immobilize labile sea buckthorn carotenoids or polyphenols, forming an occlusive film that reduces TEWL and sustains release [27,28].

Notably, enhanced cutaneous deposition from nanocarriers primarily reflects improved active partitioning and lipid fluidization rather than intact nanoparticles traversing the entire dermis; performance must be substantiated via quantitative skin-layer retention and imaging studies [27,29].

5.4. Polymeric Matrix Films and Transdermal Patches

Polymeric matrices fabricated from hydroxypropyl methylcellulose (HPMC), hydroxypropyl cellulose (HPC), Carbopol, polyvinyl alcohol (PVA), polyvinylpyrrolidone (PVP), and ethyl cellulose regulate active release from topical films and matrix-type patches [16,50]. A matrix patch typically integrates an occlusive backing membrane, a drug-loaded polymer matrix, a pressure-sensitive adhesive layer, and a removable release liner. While topical anti-aging films target localized epidermal/dermal delivery, regulatory boundaries distinguishing cosmetic topical patches from systemic transdermal drug delivery systems must be strictly

maintained [16].

6. Physicochemical, Rheological, and Diffusion Characterization

Comprehensive physicochemical characterization establishes formulation reproducibility, stability, and quality [16,42]. Equilibrium saturation solubility is measured across distilled water, phosphate buffer (pH 5.5–7.4), ethanol, propylene glycol, and pharmaceutical oils using validated HPLC or UV-visible methods [45]. ICH Q1A(R2) stability studies monitor organoleptic appearance, pH, viscosity, phase separation, peroxide value, microbial quality, and HPLC marker assay under light-protected storage [42].

Although the octanol–water partition coefficient (log P) provides an initial index of lipophilicity, percutaneous transport depends on molecular weight, ionization, hydrogen bonding, and vehicle thermodynamic activity according to Fick's first law of diffusion [7,31,32]:

$$J = -D\,(dC / dx) \quad \text{and} \quad Jss = dQ / (A \cdot dt)$$

where J is diffusion flux, D is diffusion coefficient, dC/dx is concentration gradient, Jss is steady-state flux, Q is cumulative amount permeated, A is exposed skin surface area, and t is time [31,32]. Rheological profiling—measuring Brookfield viscosity, spreadability, extrudability, yield stress, and thixotropy—ensures pleasant skin feel, while dynamic light scattering (DLS) characterizes nanocarrier hydrodynamic diameter, polydispersity index (PDI < 0.3), and zeta potential [27,33].

7. In Vitro Release and Ex Vivo Skin Permeation Studies

In vitro release testing (IVRT) using synthetic membranes and ex vivo in vitro permeation testing (IVPT) using excised porcine or human skin in vertical Franz diffusion cells follow OECD Test Guideline 428 [13,31,32]. As illustrated in Figure 2A, the skin membrane is mounted between donor and receptor compartments maintained at a physiological skin surface temperature of 32 ± 0.5°C under continuous magnetic stirring, maintaining sink conditions via periodic sampling and fresh buffer replacement.

Figure 2. Ex Vivo Franz Diffusion Cell Permeation Setup (OECD 428) and ICH Q8(R2) Quality by Design (QbD) Loop

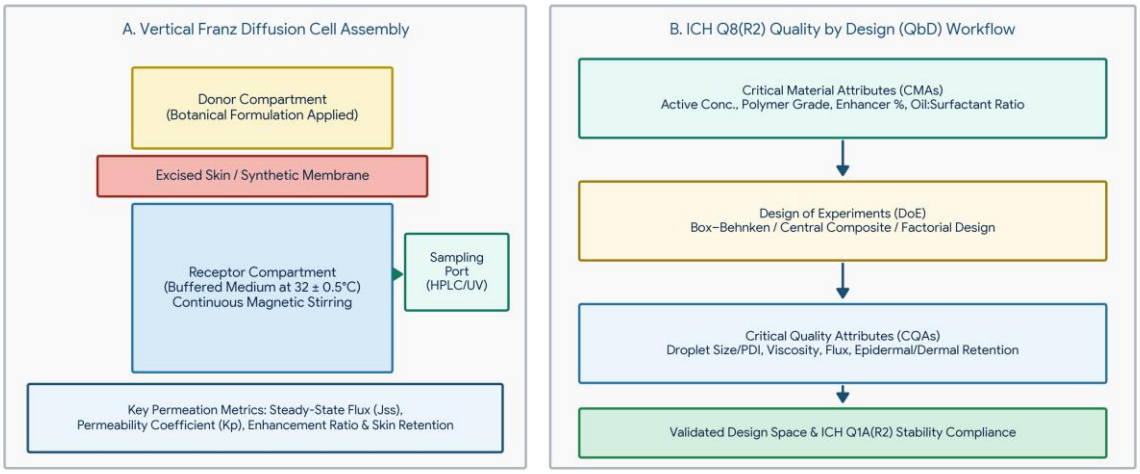


Figure 2. *Ex vivo vertical Franz diffusion cell permeation setup (OECD 428) (A) and ICH Q8(R2) Quality by Design (QbD) optimization workflow (B).*

Cumulative permeation per unit area (Qn), permeability coefficient (Kp), and enhancement ratio (ER) are calculated as [31,32]:

$$Qn = [Cn \cdot Vr + Vs \cdot \sum Ci] / A \quad | \quad Kp = Jss / Cd \quad | \quad ER = Jformulation / Jcontrol$$

Upon completion of diffusion runs, differential tape-stripping and tissue extraction quantify active retention within the stratum corneum, viable epidermis, and dermis—the critical efficacy endpoint for anti-aging products [32,34]. Release data are fitted to zero-order, first-order, Higuchi, and Korsmeyer–Peppas models to elucidate transport mechanisms [33, 77-80].

8. In Vivo Safety, Clinical Bioengineering, and Quality by Design (QbD)

Botanical origin does not automatically guarantee dermatological safety; plant extracts and surfactants can provoke irritant or allergic contact dermatitis [14,20]. Preclinical biocompatibility combines reconstructed human

epidermis (RhE) irritation testing (OECD Test Guideline 439) with human repeat-insult patch testing [14, 81-83]. Clinical anti-aging outcomes are quantified non-invasively using standardized biophysical instrumentation detailed in Table 3 [4,5]. Notably, a 2025 systematic review and meta-analysis of randomized controlled trials reported statistically significant improvements in stratum corneum hydration and overall skin elasticity following topical plant-based interventions, while emphasizing the need for rigorous clinical trials to confirm consistent effects on TEWL and deep wrinkle profilometry [5, 71-76].

Table 3. Non-Invasive Instrumental and Clinical Parameters for Evaluating Cutaneous Anti-Aging Efficacy

Clinical / Biophysical Parameter	Instrumental Evaluation Method	Physiological & Anti-Aging Relevance
Stratum Corneum Hydration	Corneometer (capacitance measurement)	Quantifies epidermal moisture retention and restoration of natural moisturizing factors
Transepidermal Water Loss (TEWL)	Tewameter (open-chamber vapor flux)	Evaluates integrity and recovery of the intercellular lipid skin barrier
Skin Elasticity & Firmness	Cutometer (suction-deformation viscoelastometry)	Measures biomechanical recovery and preservation of dermal elastin and collagen
Wrinkle Depth & Microrelief	Optical 3D skin imaging / silicone profilometry	Quantifies reduction in fine lines, periorbital wrinkle depth, and surface roughness
Melanin & Erythema Index	Mexameter (narrow-band reflectance)	Monitors uneven hyperpigmentation, photo-tanning, and subclinical erythema
Surface Texture & Scaling	High-resolution dermoscopy / Visioscan	Evaluates desquamation, smoothness, and overall epidermal renewal

Applying Quality by Design (QbD) under ICH Q8(R2) and Quality Risk Management under ICH Q9(R1) (Figure 2B) maps Critical Material Attributes (active concentration, polymer grade, enhancer level, lipid-to-surfactant ratio) and Critical Process Parameters (homogenization speed, temperature) onto Critical Quality Attributes (particle size, PDI, viscosity, flux, dermal retention) via Box–Behnken or central composite Design of Experiments (DoE) [15,33,43, 57-60].

9. Regulatory, Ethical, and Future Translational Perspectives

In India, botanical cosmetic formulations are regulated under the Drugs and Cosmetics Act, 1940, and the Cosmetics Rules, 2020, whereas products making therapeutic claims fall under CDSCO drug or phytopharmaceutical frameworks, alongside US FDA guidance for transdermal and topical delivery systems [16, 61-64]. Clinical investigations require Institutional Ethics Committee approval and informed consent, while justified animal studies must comply with CPCSEA guidelines and the 3Rs principles.

Future research in botanical transdermal anti-aging delivery should prioritize: (1) LC-MS and HPTLC marker standardization of sea buckthorn and polyherbal extracts; (2) layer-targeted hybrid nanocarriers (NLC-emulgels, deformable transfersomes, and microneedle-assisted systems) [17,44, 65-70]; (3) biodegradable green excipients and airless antioxidant packaging; and (4) multicenter randomized controlled clinical trials establishing long-term efficacy and safety [5,51–53].

10. Conclusion

Botanical bioactive compounds—exemplified by sea buckthorn carotenoids, tocopherols, resveratrol, green tea catechins, curcumin, and Centella asiatica triterpenoids—offer potent multi-pathway protection against intrinsic and extrinsic skin aging. Integrating these phytoconstituents into rationally engineered transdermal and topical platforms, including permeation-enhanced hydrogels, emulgels, liposomes, transfersomes, ethosomes, SLNs, NLCs, and nanoemulsions, overcomes solubility, stability, and stratum corneum permeability barriers. Rigorous physicochemical characterization, OECD 428 Franz diffusion retention studies, OECD 439 biocompatibility screening, ICH Q8(R2) QbD optimization, and standardized clinical bioengineering evaluations provide a robust scientific foundation for developing safe, reproducible, and clinically validated botanical anti-aging therapeutics.

References

1. Farage MA, Miller KW, Elsner P, Maibach HI. Intrinsic and extrinsic factors in skin ageing: a review. Int J Cosmet Sci. 2008;30(2):87-95. doi:10.1111/j.1468-2494.2007.00415.x.
2. Kammeyer A, Luiten RM. Oxidation events and skin aging. Ageing Res Rev. 2015;21:16-29. doi:10.1016/j.arr.2015.01.001.
3. Rittié L, Fisher GJ. Natural and sun-induced aging of human skin. Cold Spring Harb Perspect Med. 2015;5(1):a015370. doi:10.1101/cshperspect.a015370.
4. Williams AC, Barry BW. Penetration enhancers. Adv Drug Deliv Rev. 2004;56(5):603-618. doi:10.1016/j.addr.2003.10.025.
5. Benson HAE. Transdermal drug delivery: penetration enhancement techniques. Curr Drug Deliv. 2005;2(1):23-33.
6. Efficacy and safety of topical application of plant-based products on skin aging in healthy individuals: a systematic review and meta-analysis of randomized controlled trials. J Cosmet Dermatol. 2025;24(2):e16710. doi:10.1111/jocd.16710.
7. Raghav RS, Verma S, Monika. A comprehensive review on potential chemical and herbal permeation enhancers used in transdermal drug delivery systems. Recent Adv Drug Deliv Formul. 2024;18(1):21-34. doi:10.2174/0126673878272043240114123908.
8. Organisation for Economic Co-operation and Development. Test No. 428: Skin absorption: in vitro method. Paris: OECD Publishing; 2004. doi:10.1787/9789264071087-en.
9. Gaikwad SS, Zanje AL, Somwanshi JD. Advancements in transdermal drug delivery: a comprehensive review of physical penetration enhancement techniques. Int J Pharm. 2024;652:123856.
10. Cosmeceuticals in photoaging: a review. Skin Res Technol. 2024;30(9):e13730. doi:10.1111/srt.13730.
11. Chhajed M, Rathore AS, Chhajed AJ, Lodha RJ, Yadav J, Sinha P, Bukkawar A, Patil P, Wathore S, Dubey I. Impact of National Education Policy 2020 on Internationalization of Pharmacy Education in India: Progress, Opportunities and Challenges.
12. Yadav J, Gupta D, Chhajed M, Rathore AS. Artificial Intelligence-Driven Design and Optimization of Micro needle-Based Drug Delivery System: A Review. International Journal of Advanced Research in Science, Communication and Technology. 2025 Oct;5(1):920-
13. Chhajed M, Rathore AS, Dulkar D, Sharma G. Autonomus Incident Remediation: A Closed Analytical Methods Validation in Pharmaceutical Analysis From Assumption to Realistic Optimization : A Review. International Journal of Advanced Research in Science, Communication and Technology. 2025 June; 5(8):737
14. Chhajed M, Chhajed AJ, Lodha RJ, Rathore AS, Bukkawar A, Mandloi M. Chronobiology and its Relevance to Drug Administration : Advancing Chronotherapeutic for Precision Medicine. International Journal of Advanced Research in Science, Communication and Technology. 2025 Dec;5(1):850
15. Chhajed M, Chhajed AJ, Rathore AS, Dwivedi SK, Verma Swapnil. Phytochemical Investigation and Pharmacological Evaluation for Antimicrobial, Anthelmintic and Antioxidant Activity of Solanum xanthocarpum Sehrad & Wendl. International Journal of Advanced Research in Science, Communication and Technology. 2026 Jan;6(4):767
16. Chhajed M, Rathore AS, Chouhan S, Mandloi M, Waghela R. Potential Herbal Drugs for the Treatment of Epileptic Seizures:A Review. International Journal of Advanced Research in Science, Communication and Technology. 2025 March;5(8):620
17. Dulakar D, Sinha P, Yadav J, Ahirwar S, Rathore AS, Chhajed M. Phytochemical Study of Murraya Koenigii:A Review. International Journal of Advanced Research in Science, Communication and Technology. 2026 Feb;6(3):758
18. Rathore AS, Chhajed M, Rathore M, Yadav J, Patidar M, Jain A. Antioxidants in Indian Culture: A Comprehensive Study. International Journal of Advanced Research in Science, Communication and Technology. 2025 May;5(10):543
19. Chhajed M, Rathore AS, Jain A, Tanwar A, Patidar M. Formulation and Evaluation of Nanosuspension for Solubility and Dissolution Enhancement of Poorly Water soluble drugs. International Journal of Advanced Research in Science, Communication and Technology. 2025 July;5(1):794
20. Rathore AS, Chhajed M, Sinha P, Tanwar A, Awasthy A, Patidar Rajnandni. Anti- Aging: the way You Manage The Age. International Journal of Advanced Research in Science, Communication and Technology. 2025 Jan;5(2):807
21. Chhajed M, Rathore AS, Patil S, Patel AL, Kushwah N. Formulation and Evaluation of Rutin Phytosomes. International Journal of Advanced Research in Science, Communication and Technology. 2026 March;6(1):761
22. Rathore AS, Panwar AS. Formulation Optimization and Biological Evalution of Spinach based Glutathione Mouth Dissolving Granules for Anti Aging Potential. Journal of Health Synape. 2026 Oct;1(4):33- 48
23. Gandhi MY, Prasad SB, Kumar V, Soni H, Rawat H, Mishra SK, et al. Quantification of phytochemicals and metal ions as well as the determination of volatile

compounds, antioxidant, antimicrobial and antacid activities of the *Mimosa pudica* L. leaf: Exploration of neglected and under-utilized part. Chem Biodivers. 2023;20(10):e202301049.
24. Shamim, Ali S, Ali T, Sharma H, Kishor BN, Jha SK. Recent advances in monodisperse gold nanoparticle delivery, synthesis, and emerging applications in cancer therapy. Plasmonics. 2025;20(9):7121–41.
25. Jha SK, Singh N, Shanker OR, Antil I, Baghel JS, Huddar V, et al. A review on integrative approaches in oncology: Bridging Ayurvedic medicine and modern cancer therapeutics. Front Nat Prod. 2025;4:1635197.
26. Sharma S, Kumar C, Kushwaha H, Jha SK, Chawla S, Sharma A, et al. Advancing anticancer drug development: Overcoming challenges and exploring new therapeutic strategies. Ayush J Integr Oncol. 2025;2(1):8–27.
27. Gandhi Y, Kumar V, Singh G, Prasad SB, Mishra SK, Soni H, et al. Chemoprofiling and medicinal potential of underutilized leaves of *Cyperus scariosus*. Sci Rep. 2024;14(1):7263.
28. Singh A, Jha SK, Dwivedi PC, Srivastava U, Pal A. Revolutionizing healthcare: Integrating electronics, AI, traditional, and conventional methods. World J Adv Res Rev. 2024;23:2426–34.
29. Jha SK, Islam M, Kumar R, Rana L, Saifi MA, Ali S, et al. Evaluation of *Vernonia amygdalina* Del. containing phytoconstituents as potential inhibitors of monkeypox virus using molecular docking analysis. World J Adv Res Rev. 2023;17(1):1112–22.
30. Jha SK, Mishra AK, Kumar V, Dane G, Kumari S, Charde V, et al. Ecological and behavioral impacts of COVID-19 on human existence and potential preventive measures through traditional and alternative medicine: A narrative review. Pharmacol Res Nat Prod. 2024;3:100042.
31. Sonawane SM, Lohiya GV, Rao AK, Beniwal M, Chavan SU, Aparadh VM, et al. Conjunctivitis in unusual populations: A review of rare cases and challenges in diagnosis and management. World J Adv Res Rev. 2023;19(3):1326–36.
32. Khan R, Maheshwari D, Chauhan S, Lohiya GV, Kumar C, Antil I, et al. Exploring the potential therapeutic value of *Solanum lycopersicum* L. phytoconstituents for Parkinson's disease through molecular docking analysis. World J Adv Res Rev. 2023;20:488–501.
33. Sonkar V, Jha SK, Tiwari S, Akarsh A, Priya S, Sharan P, et al. Characterization and explanation of the soil fertility state of Sakaldiha block in the Chandauli District of Uttar Pradesh's industrial area. World J Adv Res Rev. 2023;18:63–72.
34. Singh NK, Sengar AS, Jha SK. A review of Ayurvedic measures for preventing COVID-19 and promoting health during pregnancy. J Indian Syst Med. 2024;12(2):61–5.
35. Trivedi LM, Saxena S, Sharma S, Beniwal M, Jha SK, Rao AK, et al. Characterization, profiling, and molecular docking analysis of phytochemicals derived from *Daucus carota* for evaluating their potential role in cardiovascular disease assessment. World J Adv Res Rev. 2023;20:159–75.
36. Mehta V, Zargar AA, Attri P, Jha SK. Bagging the role of herbal drugs in the management of cervical cancer. Ayush J Integr Oncol. 2025;2(1):35–43.
37. Chauhan S, Jha SK, Tamta A, Sharma V, Kumar C, Lohiya G, et al. Descriptive analytical study based on profiling, morphological, pomological and pharmacological traits to identify the genotypes of the promising mango *Mangifera indica* L. World J Adv Res Rev. 2023;19:1544–53.
38. Tamta, Arnima, and Sudhanshu Kumar Jha. "Screening of Germplasms and Population Dynamics of Major Insect Pests of Spring Green Gram Vigna radiata (Linn.)." PhD diss., Doctoral Dissertation, Doctoral Dissertation, GB Pant University of Agriculture and Technology, Pantnagar-263145 (Uttarakhand).
39. Kumar R, Verma H, Ali M, Midha T, Kumar D, Jha SK. Review of mitigating cancer risk through Ayurvedic practices: A holistic approach to combating sedentarism. Ayush J Integr Oncol. 2025;2(2):86–90.
40. Patel S, Singh S, Gupta AK, Dalimbe AY, Muthoju SM, Pawar AR, et al. Ayurveda and common Indian spices: A natural alternative for cancer therapy. Ayush J Integr Oncol. 2025;2(2):91–102.
41. Jha KT. Stereoisomerism in chemistry and drug development: Optical, geometrical, and conformational isomers. 2025.
42. Jha SK, Gupta A, Huddar VG. Botanical breakthroughs: The growing impact of plant-derived compounds in cancer treatment. Ayush J Integr Oncol. 2025;2(2):62–7.
43. Sharma A, Jha SK, Huddar VG. Integrative role of Ayurvedic phytochemicals in cancer treatment: Targeting signaling pathways, boosting chemosensitivity, and utilizing traditional therapeutics. Ayush J Integr Oncol. 2025;2(2):77–85.
44. Jha SK, Charde V, Kumar V, Narasimhaji CV. Vitiligo treatment with natural bioactive: A narrative review. Nat Prod J. 2026;16(3):e22103155337960.
45. Zargar AA, Mehta V, Gupta R, Bhandari K, Sharma MC, Balaji P, et al. Incretin hormones: Mechanisms, therapeutic implications, and future directions in glucose regulation and diabetes management. Curr Proteom. 2025;22:100014.

46. Doshi R, Lohiya G. Synthesis, in-silico design and spectral characterization, elucidation of *Cannabis sativa* L. (Cannabaceae) containing phytoconstituents demonstrating novel therapeutic efficacy against epilepsy.
47. Shrivastav S, Tyagi R, Singh M, Jha S. The effectiveness of curcumin on dysmenorrhea. Int J Med Sci Pharma Res. 2022;8(4):8–12.
48. Sharma S, Yadav C, Chawla S, Jha SK. Beyond chemotherapy: Exploring the potential of phytomedicine in oncology. Ayush J Integr Oncol. 2025;2(3):133–45.
49. Badal R, Ranjan S, Jha SK, Kumar L, Patel AK, Yadav P, et al. GC-MS/MS and HR-LCMS-QTOF analysis of various extracts of Saraswata Ghrita: A comprehensive dataset on phytochemical compounds. Data Brief. 2025;61:111675.
50. Ahlawat A, Chauhan S, Antil I, Jha SK, Huddar VG. Examining the impact of the microbiome on cancer immunotherapy outcomes: A review. Ayush J Integr Oncol. 2025;2(3):118–24.
51. Gupta AJ, Huddar VG, Jha SK, Soni U. Traditional wisdom in modern oncology: Ayurvedic pain relief and supportive care. Ayush J Integr Oncol. 2025;2(3):178–87.
52. Sandrepogu J, Khandelwal P, Tiwari SK, Jha SK, Chauhan S, Sharma H, et al. A holistic paradigm for cancer care: Merging Ayurveda with contemporary oncology. Ayush J Integr Oncol. 2025;2(4):254–61.
53. Antil I, Bangarwa S, Jha SK, Gupta AJ, Soni U, Huddar VG, et al. Exploring the chemopreventive and anticancer effects of green tea. Ayush J Integr Oncol. 2025;2(3):158–68.
54. Attri P, Zargar AA, Mehta V, Mushtaq SU, Jha SK, Soni U. Genetic basis of cancer: Harnessing natural remedies for therapeutic potential. Ayush J Integr Oncol. 2025;2(3):188–94.
55. Chauhan S, Jha SK, Huddar VG, Ahlawat A, Sharma S, Tripathi A, et al. Targeting cancer at the molecular level: A biochemical and medicinal chemistry approach. Ayush J Integr Oncol. 2025;2(3):169–77.
56. Pandey JK, Verma SK, Kumar J, Perwej Y, Jha SK, Panchal BY, et al. Transformative role of advanced neural computation in clinical image diagnostics: A review of key concepts and applications. Semin Ultrasound CT MR. 2026;47(5):374–90.
57. Sharma H, Mahto RR, Jha SK, Chauhan S, Khandelwal P, Tiwari SK. Rasayana-based adjuvant strategies in cancer care: An Ayurvedic-oncologic perspective. Iran J Blood Cancer. 2025;17(4):35–68.
58. Raj H, Sharma S, Tripathi A, Huddar VG, Jha SK. Herbal medicine in cancer therapy: A comprehensive review of phytoconstituents, mechanisms, and clinical applications. Ayush J Integr Oncol. 2025;2(3):146–57.
59. Shamim PT, Khatri N, Yadav AK, Mishra B, Khan MR, Behera SK, et al. Role of human chorionic gonadotropin in frozen-thawed embryo transfer cycles for secretory transformation: A narrative review. Eur Chem Bull. 2023;12(8):5477–93.
60. Mandal P, Kumar J, Bora D, Hashmi SA, Tiwari M, Gupta R, et al. Literature review on forensic implications of illicit drug metabolism: A medicinal chemistry perspective. J Forensic Leg Med. 2026;103158.
61. Kumar C, Chauhan P, Chauhan S, Jha SK, Lohiya G. Phyto-pharmacognostic experimental study of *Epimedium sagittatum* and *Gloriosa superba* L. for the treatment of hypogonadism. Int J Innov Sci Res Technol. 2023;8(6):254–60.
62. Raj H, Jha SK, Negi M, Khandelwal P, Chauhan S, Sharma H, et al. Integrative oncology: A comprehensive comparative analysis of herbal and allopathic medicine in cancer treatment. Curr Pharm Res. 2025;1:427–35.
63. Dhiman S, Thakur N, Dwivedi PC, Pande P, Jha SK, Lohiya GV. Phytochemicals: Investigating bioactive compounds for antifungal uses and quality issues in functional foods and therapeutics. 2024:258–68.
64. Singh V, Mandal P, Kaur N, Bora D, Gupta R, Kumar A, et al. Synthesis, characterization, and binding interactions of rhodanine-3-acetic acid-based compound for latent fingerprint development. J Forensic Sci. 2026;71(1):584–92.
65. Jha SK, Chaturvedi SK, Singh SK, Chauhan S, Chauhan P, Singh H, et al. Synthesis and in-silico design of a novel silver metal ciprofloxacin compound. World J Adv Res Rev. 2023;18(1):885–92.
66. Mahto RR, Bansal KS, Soni H, Tiwari SK, Sandrepogu J, Bhatted SK. Efficacy of Vidangadi Loha and Phalatrikadi Ghana Vati with and without the prior administration of Virechana Karma in Madhumeha (obese diabetic): A randomized controlled trial. Int J Drug Deliv Technol. 2026;16(41s):1275–81.
67. Shivani, Thakur N, Lohiya GV, Gupta R, Dhiman S, Bharadwaj S, et al. Natural origins, bioavailability and therapeutic potential of astaxanthin: A systematic review across diverse health applications. 2024:5929–39.
68. Tamta A, Jha SK. Implications of green technology for climate change mitigation minimizing waste and pollution. TIDEE. 2023;22(4):476.
69. Kaur AK, Venkatasubramanian H, Sarma S, Gupta R, Singh RG, Chaudhary B, et al. Targeting cancer pathways with phytochemicals: Molecular mechanisms and clinical potential. Curr Proteom. 2026;23(6):100182.
70. Patel S, Paliwal A, Jha SK, Singh R, Mishra AK. Environmental neurotoxicants as accelerators of brain ageing: Exposomic mechanisms linking pollution to

amyloidogenesis and Alzheimer's disease. Int J Environ Health Res. 2026:1–21.
71. Dhiman S, Thakur N, Jha SK, Karkare P, Bora D, Sahu RK, et al. Pyrazole derivatives: A comprehensive review of synthesis, antimicrobial activity, structure-activity relationships, and therapeutic potential. Curr Proteom. 2026;23(5):100154.
72. Mundada AB, Mundada PA, Kathirvel S, Kumar PR, Krishnamoorthy P, Ezzaoui N, et al. Ion channels as emerging drug targets: Pharmacological insights and therapeutic advances. Curr Proteom. 2026;23(4):100141.
73. Midha T, Kumar D, Kumar A, Jha SK. Rasayana therapy in Ayurveda: A promising approach for cancer support and immunomodulation. [Publication details required].
74. Garg N, Sharma R, Bhojani MK, Rai S, More AB, Jha SK. Bridging traditional wisdom and modern science: An integrative approach to breast cancer care. Ayush J Integr Oncol. 2026;3(2):81–9.
75. Jha SK, Negi M, Singh K, Shukla D, Sharma H, Khandelwal P, et al. Harmonizing traditional Ayurvedic knowledge with modern science: A comprehensive review. Curr Pharm Res. 2026:393–410.
76. Antil I, Jha SK, Negi M, Sharma H, Tiwari SK. Baicalein from *Scutellaria baicalensis* as natural therapeutic agent for glioblastoma. Curr Pharm Res. 2025;1:411–26.
77. Mahto RR, Sharma H, Bhatted SK, Jha SK, Tiwari SK, Chauhan S, et al. Diabetes and erectile dysfunction: Exploring the Ayurvedic understanding of Madhumehaj Klaibya. Curr Pharm Res. 2026:446–57.
78. Gangurde RB, Goel P. Approach towards type 2 diabetes mellitus-induced erectile dysfunction (DMED): A case study.
79. Panwar AS, Rathore AS, Kaithwar K, Dhokpande A. Nanoengineered Drug Delivery Systems to Overcome Multidrug Resistance in Cancer. Journal of Health Synape. 2026 June;1(2):65-74
80. Rathore AS, Panwar AS, Dongre N. International Journal of Taxicological and Pharmacological Research. 2021 April;11(2):37-45
81. Baghel JS, Maheshwari RK. Novel application of mixed solvency concept in the development of fast dissolving solid dispersion of poorly water-soluble drug, torsemide and its evaluations. World J Pharm Res. 2020;9(1):1820-1839. doi:10.20959/wjpr20201-16587.
82. Maheshwari RK, Jain S, Padria A, Mulani P, Baghel JS, Maheshwari N. Eco-friendly extraction using solids: a novel application of mixed solvency concept. J Drug Deliv Ther. 2019;9(2):244-249. doi:10.22270/jddt.v9i2.2409.
83. Kushwah P, Jain G, Patidar A, Baghel JS, Agarwal A. From ancient remedies to modern marvels: unveiling the medicinal secrets of Nyctanthes arbor-tristis and Piper betle Linn. leaves - a comprehensive review. Int J Pharm Sci Med. 2023;8(12):11-24. doi:10.47760/ijpsm.2023.v08i12.002.