INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES
[ISSN: 0975-4725; CODEN(USA): IJPS00]
Journal Homepage: https://www.ijpsjournal.com

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Review Article

Formulation Variables, Physicochemical Stability, and Skin Permeation of Curcumin-Loaded Phytosomal Gels: A Critical Review

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ARTICLE INFO

Published: 27 Nov 2026
Keywords:
curcumin, phytosome, phospholipid complex, topical gel, physicochemical stability, skin permeation, Carbopol
DOI:
10.5281/zenodo.24580556

ABSTRACT

Curcumin, the principal curcuminoid of *Curcuma longa*, has well-documented Its anti-inflammatory, antioxidant, wound-healing, and anti-proliferative properties make it appealing for use in dermatology. However, its poor penetration into the stratum corneum, chemical instability at neutral-alkaline pH and under light, and extremely low water solubility restrict its topical efficiency. Phytosomes, also known as phyto-phospholipid complexes, are a proven method for enhancing the solubility, stability, and membrane affinity of polyphenols; adding them to a gel foundation results in a dosage form that is patient-friendly and simple to administer. Using data from curcumin phytosome studies, phytosome reviews, and similar vesicular and gel systems, this review critically investigates (i) the formulation variables that control the quality of curcumin phytosomes and the final gel, (ii) the physicochemical stability of curcumin and of the phytosome–gel system, and (iii) skin permeation and retention behaviour. One of the main conclusions is that there are still few direct research on curcumin phytosomal gels; much of what is known must be deduced from oral curcumin–phospholipid complexes, curcumin vesicles in gels, and phytosomal gels of other polyphenols. There are gaps in clinical data, skin model standardisation, and stability testing, and suggestions for further research are made.

INTRODUCTION

Although curcumin has been thoroughly investigated for inflammatory, cancerous, and dermatological disorders, its low bioavailability has hindered its clinical translation [1-3]. Because topical administration can carry the molecule directly to the target tissue and avoid substantial first-pass metabolism, reviews of its usage in skin problems (atopic dermatitis, psoriasis, wounds, photoaging, and skin cancer) support it as a rational approach [4–6]. However, simple curcumin creams and gels don't work well, and in an early

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Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

vesicle-based investigation, even large loadings in conventional bases didn't provide a significant antioxidant or anti-aging benefit [32].

This is explained by three fundamental issues. First, curcumin has an aqueous solubility of ng/mL and is a lipophilic, high-melting solid. Second, it breaks down by photolysis, autoxidation, and hydrolysis [7–10]. Third, it needs to get through the stratum corneum, which prevents most molecules from passing through, much like any topical active [14,15]. For topical curcumin, formulation science has so investigated liposomes, niosomes, ethosomes, transfersomes, invasomes, micro- and nano-emulsions, lipid nanocarriers, cyclodextrin complexes, and polymeric gels [11,40–47].

Among these systems, phytosomes have a unique place. The phrase describes complexes that are created when a phytoconstituent and a phospholipid—typically phosphatidylcholine (PC)—interact, with the polar head of the phospholipid interacting with the polar functional groups of the active while the fatty acid chains stay free [22–24]. In contrast, a liposome does not have a defined molecular complex; instead, the active is just confined inside or between bilayers [24]. The most well-known commercial example is the lecithin formulation of curcumin (Meriva®) [29, 30]. The idea was first developed for cosmetic and dermatological usage prior to its oral uses [17, 19].

The topical gel format is the main theme of this review. Its goals are to examine the available physicochemical stability data, combine the formulation factors that regulate phytosome and gel quality, and critically analyse skin penetration evidence.



Figure 1: ***Progression from the botanical source (Curcuma longa rhizomes) to isolated crystalline curcumin powder and a translucent, patient-friendly curcumin-loaded topical phytosomal gel formulation.***

1.1 Scope and literature approach

This review is narrative in nature. Using combinations of the terms curcumin, phytosome, phospholipid complex, phosphatidylcholine, topical gel, skin permeation, stability, and Carbopol, web-based searches of open-access and PubMed/PMC-indexed journals were used to find sources. The reference lists of important reviews were then added. After reading reviews on phytosomes and curcumin administration, original research that reported formulation factors, stability, or penetration data were read. Evidence from similar systems is used and tagged as such because no one research for curcumin phytosomal gels was found to address all three aspects.

2. Curcumin: Properties Relevant to Topical Formulation

Physicochemical profile: Curcumin is lipophilic (log P = 2.9), which promotes skin retention but not water solubility [42]. Its molecular weight is about 368 Da. It crystallises from aqueous media at acidic pH and exists as keto and enol tautomers whose balance is dependent on pH [10,11].

Chemical instability: It was discovered that pure curcumin crystallises from acidic solutions and is extremely unstable in alkaline aqueous solutions (pH > 7.0) [10]. Vanillin, ferulic acid, and feruloylmethane are minor results of autoxidation at physiological pH, while bicyclopentadione is the primary product [8,9]. By combining hydrolytic and oxidative fragmentation, light speeds up deterioration [7,9,12]. Compared to curcumin, a number of these breakdown products have

lower biological activity [9]. Encapsulation is one of the best methods to prevent curcumin from degrading while increasing dispersibility, according to reviews of formulation techniques [11,13].

Pharmaceutical consequence: Any topical curcumin gel has to be made with a carefully regulated pH that ranges from slightly acidic to neutral, shielded from light, and assessed using a stability-indicating test that can distinguish curcumin from its breakdown products [12].

2.1 Mechanisms of action in skin

The use of curcumin in dermatology is based on its antioxidant action and decreased production of pro-inflammatory cytokines, according to reviews [4,5]. A topical curcumin nanoemulsion gel corrected paw oedema and joint thickness while lowering TNF-α and IL-1β levels in a rat arthritic model [42]. Combined antioxidant, anti-inflammatory, and antibacterial actions that act throughout the inflammatory, proliferative, and maturation stages are responsible for wound-healing activity [5,6].

2.2 Dermatological indications explored

Condition	Rationale for topical curcumin	Source
Psoriasis	Suppression of inflammation and keratinocyte proliferation	[4]
Atopic dermatitis	Anti-inflammatory and antioxidant action	[4]
Acute and chronic wounds	Faster healing through antioxidant and antimicrobial effects; sustained delivery by hydrogels	[5,6]
Photoaging and UV-induced oxidative stress	Antioxidant and anti-wrinkle effect shown with curcumin–PC complex and phyto-vesicles in a gel (mouse model)	[32]
Localised inflammation, e.g. arthritis	Reversal of arthritic signs with curcumin nanoemulsion gel (rat model)	[42]
Skin cancer	Antiproliferative activity; the need for a suitable topical formulation is repeatedly highlighted	[4]

Most efficacy data come from animal models, and well-controlled human topical trials are limited [4,5].

3. Phytosome Technology

3.1 Structure and rationale

Phytosomes are said to have a superior stability profile than liposomes since the active is attached to the phospholipid head group and the two fatty-acid chains do not participate in complex formation [22–24]. Better skin contact is thought to be caused by the amphiphilic complex's increased miscibility with both water and lipid phases [32]. TLC, DSC, melting point, and IR spectroscopy have all been used to characterise curcumin–phosphatidylcholine complexes, confirming complex formation as opposed to a physical mixture [32].

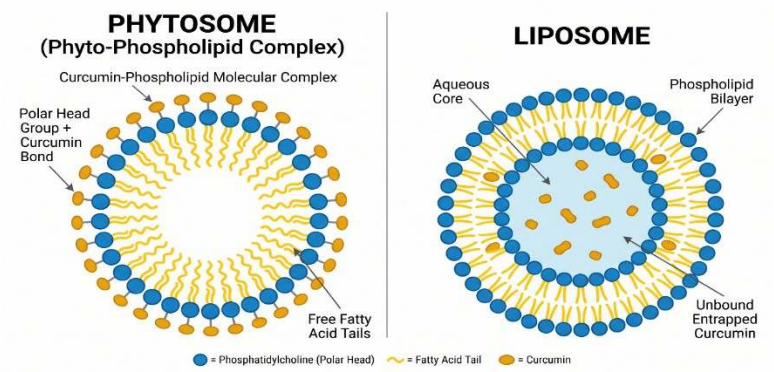

Figure 2: ***Structural distinction between a curcumin phytosome and a conventional liposome. In a phytosome, curcumin forms a defined molecular complex with the polar head group of phosphatidylcholine while the fatty acid tails remain free; in a liposome, curcumin is physically entrapped within the aqueous core or lipid bilayer without forming a specific molecular bond.***

3.2 Evidence of enhanced performance

Although only phase-2 metabolites were found in plasma, oral human data indicates that the lecithin formulation enhanced overall curcuminoid absorption by about 29 times compared to unformulated curcuminoids [30]. At every investigated dosage, a curcumin–phospholipid combination in rats demonstrated more antioxidant activity than curcumin alone [28]. Another study revealed that curcumin's systemic availability increased when phosphatidylcholine was added [29]. These findings support the idea that complexation enhances curcumin's biopharmaceutical behaviour, but they should not be immediately applied to topical performance because they deal with absorption rather than skin distribution.

3.3 Topical use of phytosomes

Phytosomes have benefits over liposomes for the skin administration of bioactive phytochemicals, according to a 2021 review on topical delivery [23]. Phytosomes were suggested as a functional cosmetic strategy [19], and early dermatological research revealed a preventive effect of silymarin–phytosome on ageing skin [17]. Phytosome formation, characterisation, and clinical translation are examined in more recent comprehensive studies [25–27].

3.4 Commercial curcumin–phospholipid products

Curcuminoids are mixed with soy lecithin and microcrystalline cellulose in a 1:2:2 ratio to create Meriva®, a lecithin-based curcumin product [13]. Oral clinical absorption data are available [30]. Although a commercial product demonstrates that curcumin–phospholipid complexation can be produced on a large scale, its evidence basis does not immediately translate to a topical gel, where performance is determined by skin partitioning and vehicle effects..

4. Formulation Variables

The quality of a curcumin phytosomal gel depends on two linked stages: preparation of the complex, then incorporation into a gel base.

4.1 Variables in preparing the curcumin–phospho- lipid complex

Variable	What the literature indicates	Source
Drug:phospholipid ratio	Complex formulations are based on weight for extracts and on molar ratio for pure actives; 1:1 curcumin:phosphatidylcholine was used in a phytosomal softgel study	[21,31]
Phospholipid type and grade	Soy PC grades (e.g. Lipoid S 100; Phospholipon 90G/90H) are common; the phospholipid choice affects size and entrapment in related vesicular systems	[31,44]
Solvent	Selection depends on the solubility of both the active and the phospholipid; protic solvents such as ethanol have been used for curcumin complexes	[21,28]
Method	Solvent evaporation is the most commonly used approach; reflux and anti-solvent routes are also reported	[24,31]
Isolation and drying	Dry free-flowing complex powder vs semisolid forms; affects later dispersion and stability	[31]

Two cautions apply. First, the ratio and solvent affect complexation efficiency, and the literature does not agree on a single optimum, so each system should be optimised experimentally. Second, a complex must be shown to be a true complex (FTIR, DSC, XRD, NMR) rather than a physical mixture [24,32].

4.2 Variables in converting the complex into a phytosomal dispersion

Vesicle size, polydispersity index (PDI), zeta potential, and entrapment/complexation efficiency become crucial quality characteristics when the complex is hydrated into a dispersion. A typical range was demonstrated by lyophilised phytosomal nanocarriers of another weakly soluble flavonoid (diosmin), which produced a particle size of 316 nm and a zeta potential of −27 mV with good stability [34]. In phytosomal and vesicular systems, design-of-experiments (such as Box-Behnken or factorial) are currently often employed to optimise such variables [35,36,44].

4.3 Variables in the gel base

Variable	Considerations	Source
Gelling agent	Carbopol grades (934, 940, 980) are the dominant choice; chitosan, hyaluronic acid and keratin–chitosan have also been used	[32,43,46,47]
pH and neutraliser	Carbopol needs neutralisation (e.g. triethanolamine), but neutral–alkaline pH accelerates curcumin degradation, so the final pH must be a compromise	[10,36]
Polymer concentration / viscosity	Controls spreadability, retention and drug release; the naringin phytosomal gel had viscosity of 1462 ± 12 cPs and 97.18 ± 0.94% drug content	[36]
Penetration enhancers and co-solvents	Propylene glycol, ethanol and oils alter stratum corneum barrier properties; their effects must be weighed against irritation and vesicle integrity	[16,17]
Vehicle polarity	In a phytosomal softgel, hydrophilic vehicles gave stable curcumin dissolution while oily vehicles caused a dramatic decrease in dissolution on storage	[31]
Preservatives and antioxidants	Needed in aqueous gels; compatibility with phospholipids should be checked	[36]

The observation in [31] is particularly important: even if a complex is stable as a powder, the vehicle in which it is dispersed can govern dissolution on storage. The same logic should be applied to topical gels.

4.4 Comparison with other topical curcumin carriers

Carrier	Key feature	Reported topical result	Source
Phytosome (curcumin–PC complex)	Molecular complex through the phospholipid head group; simple solvent-evaporation preparation	Superior anti-aging and antioxidant effect versus plain curcumin and physical mixture (mouse); vehicle-dependent stability	[24,31,32]
Elastic vesicles / transfersomes	Deformable bilayer with edge activator	About 9-fold higher flux; 51.66% skin retention in ointment	[40]
Ethosomes / transethosomes	Ethanol-containing deformable vesicles	71.3% permeation at 24 h; best stability at 5 ± 3 °C	[39,44]
Invasomes	Vesicles with terpenes and ethanol	2.60-fold higher permeation; flux 166.02 µg/cm²/h	[41]
Nanoemulsion gel	Droplets ≤ 70 nm	About 4-fold higher permeation; anti-arthritic effect in rats	[42]
Microemulsion in keratin–chitosan gel	Bioadhesive, viscoelastic gel base	Skin retention 3.75 ± 0.24 µg/cm²; no erythema or edema	[47]

Phytosomes are the only carrier in this table whose structure is a defined molecular complex rather than an entrapment or an emulsion [24]; whether that translates into better skin delivery than deformable vesicles has not been tested head to head.

5. Physicochemical Characterisation and Stability

5.1 Characterisation of the complex

FTIR (phenolic and phosphate band shifts), DSC (curcumin melting endotherm disappearance or shift), XRD (crystallinity loss), SEM/TEM (morphology), particle size, PDI and zeta potential, and entrapment/complexation efficiency are examples of standard procedures [24,31,32]. TEM of curcumin phytosomes in complex formulations revealed a spherical, self-closed shape and high stability [31].

5.2 Characterisation of the gel

Appearance, homogeneity, pH, viscosity/rheology, spreadability, medication content, in vitro release, and skin irritation are typical evaluation criteria. For instance, the keratin–chitosan curcumin gel produced neither erythema or oedema in mice and shown favourable viscoelasticity, spreadability, bioadhesion, and controlled release [47]. The identical assessment set and anti-inflammatory efficacy were reported by a naringin phytosomal gel [36].

5.3 Stability evidence

Stability of curcumin systems must be considered at three levels:

1. **Chemical stability of curcumin** – determined by pH, temperature, light and the molecular environment. Incorporation into an emulsion improved chemical stability: more than 85% of curcumin was retained after one month at 37 °C under acidic conditions, against 53–62% at pH 7.0 –8.0 [10].
2. **Physical stability of the carrier** – Vesicle size, PDI, zeta potential, leakage, aggregation, and fusion all contribute to the carrier's physical stability. For instance, a curcumin transethosome gel that was kept for 180 days demonstrated superior vesicle size and entrapment retention at 5 ± 3 °C compared to higher temperatures [44].
3. **Gel stability** – pH drift, viscosity change, syneresis, phase separation, and microbiological growth are all aspects of gel stability.

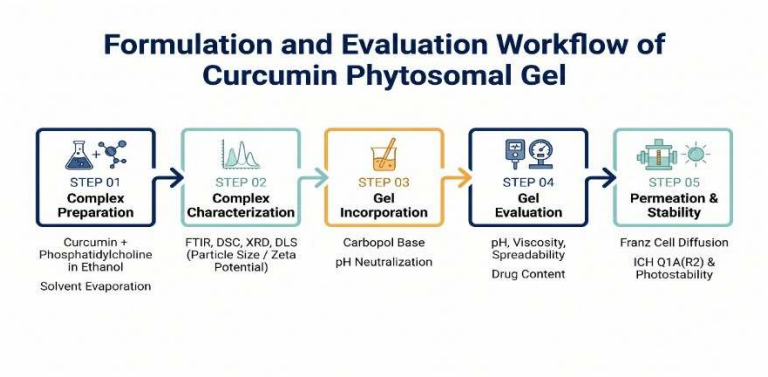

Figure 3: ***Integrated laboratory workflow for preparing, characterizing, and evaluating curcumin-loaded phytosomal gels—from solvent evaporation complexation and solid-state verification (FTIR, DSC, XRD, DLS) through Carbopol gel incorporation, rheological evaluation, ex vivo Franz diffusion cell permeation, and ICH Q1A (R2) stability testing.***

The recognised foundation for stability procedures is the ICH Q1A (R2) framework (long-term, intermediate, and accelerated circumstances) [49]. A crucial finding is that, despite the availability of stress-degradation techniques for curcuminoids, the majority of published curcumin topical trials report brief, single-condition or simply refrigerated stability, and few use forced degradation with a stability-indicating HPLC method [12]. To the best of the authors' knowledge, the literature reviewed here lacks specific long-term stability evidence for curcumin phytosomal gels.

5.4 Analytical methods

UV-visible spectrophotometry is frequently used to quantify curcumin; in a phytosomal research, curcumin concentration was determined by measuring absorbance in acetone about 420 nm [31]. For stability studies, a proven stability-indicating HPLC approach using forced-degradation samples is suggested since spectrophotometry is unable to distinguish curcumin from coloured degradation products [12]. HPLC is typically used to examine permeation samples, which have extremely low concentrations.

5.5 Suggested evaluation checklist

Parameter	Method	Why it matters	Source
Complex formation	FTIR, DSC, XRD	Distinguishes a true complex from a physical mixture	[24,32]
Size, PDI, zeta potential	Dynamic light scattering	Physical stability of the dispersed phytosome	[34]
Drug content / complexation efficiency	UV or HPLC	Dose uniformity	[31,36]
pH	pH meter	Skin compatibility and curcumin stability	[10]
Viscosity and spreadability	Viscometer, spreadability test	Application and retention	[36,47]
In vitro release	Franz cell or dialysis	Release mechanism	[47]
Ex vivo permeation and retention	Franz cell	Flux and skin deposition	[48,50]
Irritation	Animal skin test	Safety	[36,47]
Stability	ICH Q1A(R2) conditions	Shelf life	[49]
Photostability	Controlled light exposure	Curcumin is light-sensitive	[7,9]

6. Skin Permeation and Retention

6.1 Barrier considerations

For the majority of actives, the stratum corneum is the rate-limiting barrier [14, 15]. Vesicular systems were created to enhance delivery; ethosomes and similar ethanolic vesicles were created to further enhance penetration [39], and classic research shown that deformable lipid vesicles may pass the barrier under transepidermal hydration gradients [38]. An important background source is still reviews of thirty years of lipid-vesicle skin delivery studies [37].

6.2 Quantitative evidence from comparable curcumin gels and vesicles

Because direct permeation data for curcumin phytosomal gels are scarce, the following systems provide the nearest quantitative benchmarks.

System	Key permeation/retention finding	Source
Curcumin–PC complex and phyto-vesicles in Carbopol gel (mouse UV-oxidative stress model)	CU–PC complex and phyto-vesicles superior to plain curcumin and physical mixture for anti-aging, antioxidant and anti-wrinkle effect	[32]
Curcumin elastic vesicles (murine skin)	Flux about 9-fold higher than aqueous dispersion (4.14 vs 0.46 µg/h/cm²); skin retention 51.66% in ointment vs 1.64% for free curcumin ointment	[40]
Curcumin invasomal gel (pig ear skin)	Permeation 2.60-fold higher; flux 166.02 ± 0.13 µg/cm²/h	[41]
Curcumin nanoemulsion gel (droplets ≤ 70 nm)	About fourfold increase in skin permeation versus curcumin solution in oil; reversal of arthritic signs in rats	[42]
Curcumin transethosome gel (goat skin)	71.3% permeation at 24 h, 19.8% retention; vesicle size 286.4 nm	[44]
Microemulsion-based keratin–chitosan gel	Better penetration than curcumin solution; maximum skin retention 3.75 ± 0.24 µg/cm²	[47]

Care should be used when comparing these findings. Numerical fluxes are not directly comparable since the investigations utilise various skin types (goat, pig, and mouse), receptor media, curcumin loadings, and analytical techniques. Similarly, a dermatological product whose objective is local retention rather than systemic delivery may not necessarily benefit from a larger flux; as a result, retention and dermatokinetic data should be included alongside permeation [40,42,47].

6.3 Mechanistic aspects relevant to phytosomes

While the amphiphilic combination enhances the thermodynamic activity of curcumin in the vehicle, the phospholipid component may fluidise stratum corneum lipids and boost curcumin partitioning into the skin [23,32]. Although these pathways are conceivable, they have mostly been verified by activity investigations rather than direct imaging or lipid-fluidity measurements for curcumin phytosomal gels. Techniques that potentially fill this gap include tape-stripping, DSC/FTIR of treated skin, and confocal laser scanning microscopy, which have been used on comparable curcumin nanoemulsion gels [42].

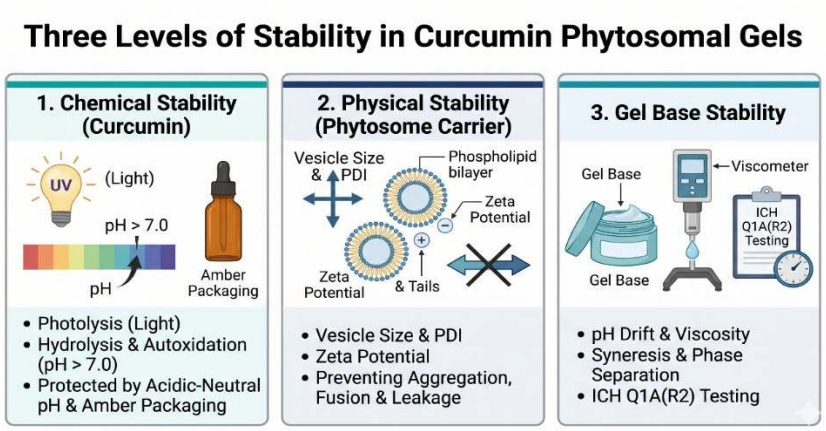

Figure 4: ***The three interdependent levels of stability governing curcumin phytosomal gels: (1) chemical stability of curcumin against photolysis and neutral–alkaline hydrolysis/autoxidation, (2) physical stability of the dispersed phytosome carrier, and (3) macroscopic stability of the hydrogel matrix under ICH Q1A (R2) testing protocols.***

6.4 Methodological aspects

The standard device is the Franz diffusion cell [48], and the in vitro skin absorption approach is described in OECD Test Guideline 428 [50]. Receptor composition (using co-solvents or surfactants to maintain sink conditions) and light protection during the experiment are crucial since curcumin is weakly soluble in aqueous receptor media, although they are frequently not sufficiently documented.

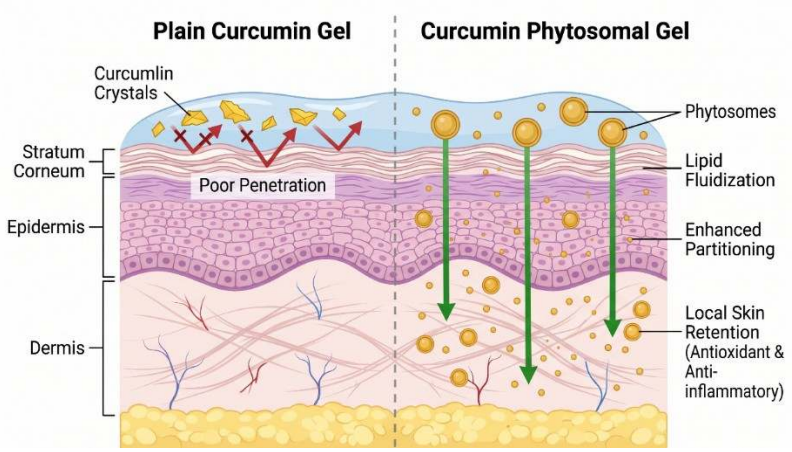

Figure 5: ***Proposed mechanism of enhanced dermal delivery from curcumin phytosomal gels compared to plain curcumin gels. While poorly soluble crystalline curcumin remains largely restricted at the stratum corneum surface, amphiphilic curcumin–phospholipid complexes fluidize stratum corneum lipids and promote partitioning and localized retention within the epidermis and dermis.***

6.5 Safety and tolerability

Animals are evaluated for irritation prior to effectiveness studies. Both the naringin phytosomal gel [36] and the curcumin keratin–chitosan gel [47] did not induce erythema or oedema in mice. The amounts of excipients including ethanol, propylene glycol, and enhancers must be justified because they have the potential to irritate and disrupt vesicle integrity [16]. Because curcumin is photoreactive [7], photo-irritation needs to be addressed. Additionally, the orange-yellow hue of curcumin gels [47] can discolour clothes and skin, which reduces patient acceptance.

7. Related Phytosomal Gels and Lessons for Curcumin

Other polyphenols' phytosomal gels provide useful models. In a carrageenan model, a naringin phytosomal gel improved by 3^2 factorial design demonstrated better diffusion and penetration compared to plain and standard gels, no erythema or oedema, and stability and anti-inflammatory efficacy [36]. Box-Behnken design was used to improve a quercetin phytosomal nanocomplex including olive oil for skin administration [35]. Additionally, a chitosan microsphere system loaded with curcumin phytosomes has been reported [33]. In-use stability is determined by vehicle choice, as demonstrated by phytosomal softgels [31]. When combined, these indicate a logical process: complicated → characterise → optimise by DoE → distribute in a gel → test permeability, retention, and stability.

7.1 Suggested laboratory workflow

The following process serves as an example and is based on the techniques in [21, 31, 32, 36, 47]; modify it to fit your laboratory's verified protocols and apparatus.

1. **Pre-formulation:** create a calibration curve and verify the authenticity of curcumin using UV, FTIR, and melting point measurements.
2. **Complex preparation:** use a suitable solvent, such ethanol, to react curcumin with phosphatidylcholine at two or three molar ratios, such as 1:1 and 1:2.
3. **Characterisation of the complex:** Complexation efficiency, FTIR, DSC, XRD, and, if available, particle size and zeta potential upon hydration are used to characterise the complex.
4. **Gel preparation:** Gel preparation involves dispersing the complex in a Carbopol (or similar) gel basis, neutralising to a pH that is suitable for skin, and then adding a preservative.
5. **Gel evaluation:** drug content, viscosity, spreadability, pH, homogeneity, and appearance.
6. **Release and permeation:** Franz cell retention measurement for both in vitro release and ex vivo permeation.
7. **Controls:** Plain curcumin gel and a curcumin–phospholipid physical combination gel, as in [32], are examples of controls.
8. **Stability:** retest pH, viscosity, drug content, and appearance at predetermined intervals and keep shielded from light under refrigerated, long-term, and accelerated settings in accordance with ICH Q1A (R2) [49].

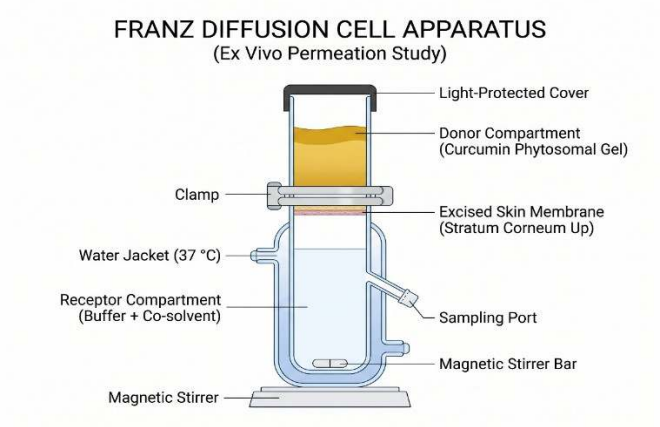

Figure 6: ***Schematic of a light-protected Franz diffusion cell apparatus used for ex vivo skin permeation and retention testing of curcumin phytosomal gels (per OECD Test Guideline 428), highlighting key methodological controls including light protection and co-solvent/surfactant receptor media to maintain sink conditions.***

8. Critical Appraisal and Research Gaps

1. **Limited direct evidence.** Few studies prepare a curcumin–phospholipid complex specifically for a topical gel and measure permeation; most evidence is oral [28–30] or comes from vesicle/emulsion gels [40–42,44].

2. **Complex vs liposome ambiguity.** Some reports label curcumin–phospholipid vesicles as phytosomes without proving molecular complexation; confirmation by spectroscopic and thermal methods is essential [24,32].
3. **Stability data are weak.** There is little long-term, ICH-style stability data and few stability-indicating assays for phytosomal gels [12,49].
4. **Non-standardised skin models and receptor media.** Mouse, pig, goat and human skin are used interchangeably, preventing comparison [40–42,44].
5. **Gel–carrier interaction.** Effects of Carbopol neutralisation, ionic strength and co-solvents on phytosome integrity and curcumin degradation are rarely tested [10,36].
6. **Efficacy and safety.** Most efficacy work is in animal models; human topical trials of curcumin are limited, and irritation and photo-safety data (curcumin is photoreactive) are sparse [4,5,7].
7. **Scale-up.** Manufacturing reproducibility is rarely addressed, although it is highlighted in recent reviews of translation [27].

9. Future Perspectives

- As suggested by recent phytosome reviews [27, 35], systematic optimisation of ratio, solvent, and procedure via quality-by-design.
- Hybrid systems that expand on ethosomal and transethosomal gels, such as phytosomes mixed with edge activators or ethanol [39, 44].
- Use of mechanistic skin studies (CLSM, tape stripping, DSC/FTIR of skin) in addition to Franz cells [42].
- Stability protocols following ICH Q1A (R2) with photostability testing and curcumin-specific degradation markers [12,49].
- Disease-specific trials (psoriasis, atopic dermatitis, wounds, photoaging) in which phytosomal gels are compared with standard topical therapy [4–6].

CONCLUSION

Curcumin phytosomal gels combine two complementing strategies: the gel provides an appropriate topical dose form, and the phospholipid complex enhances solubility and membrane affinity. The drug:phospholipid ratio, phospholipid quality, solvent and procedure for the complex, and gelling agent, pH, vehicle polarity, and enhancers for the gel are the most important formulation factors. Gel pH and packing are crucial since curcumin stability is highly dependent on pH, light, and its molecular environment. Although there is still a dearth of specific evidence on curcumin phytosomal gels, comparable vesicular gels demonstrate significant increases in flux and retention. Before this system's full potential can be assessed, standardised characterisation, ICH-compliant stability work, well-controlled permeation, and clinical trials are necessary.

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HOW TO CITE: Nirbhay Ghotekar, Adarsh Wagh, Akshada Jadhav, Priyanka Gare, Pawan Vaidya, Sarthak Nehe, Vinay Janrao, Akshay Deore, Adarsh Wagh, Formulation Variables, Physicochemical Stability, and Skin Permeation of Curcumin-Loaded Phytosomal Gels: A Critical Review, Int. J. of Pharm. Sci., 2026, Vol 4, Issue 11, 5456-5469. https://doi.org/10.5281/zenodo.24580556