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Design and Assessment of Curcumin-Impregnated Transfersomal Gel of Increased Transdermal Delivery

Dr. Leila Khatib[1], Dr. Marko Vuković[2]
[1] Department of Pharmaceutics, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2] Faculty of Pharmacy, University of Belgrade, Belgrade, Serbia
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Abstract
Curcumin is a strong natural anti-inflammatory and antioxidant agent which is well known as having therapeutical properties, but it has low aqueous solubility and low systemic bioavailability. In order to overcome these limits, this study has been designed in such a way that it will make a transfersomal gel to ramp up the transdermal absorption and also increase the therapeutic efficacy of curcumin. Transfersome was made in thin-film hydration method with phosphatidylcholine, Tween 80, and cholesterol as the surfactant and loaded into a Carbopol 940 gel base. The vesicles were reinforced with very favorable physicochemical properties with mean particle size of 134.6 nm, entrapment efficiency of 92.4 percent and a zeta potential of -32.1 mV earmarking them with a stable dispersion. In vitro drug release proffered a continuous diffusion of curcumin of 24 hours whereas the ex-vivo skin penetration study using pig ear skin showed much greater drug flux in the skin as compared to the plain curcumin gel
Keywords: ***Curcumin, Transfersomes, Transdermal Delivery, Bioavailability, Nanotechnology, Skin Permeation and Carbopol 940 Gel.***

1. Introduction

1.1 Therapeutic Potential of Curcumin and Delivery Problems Thereof

Curcumin is a bioactive polyphenolic constituent that is found in the rhizome of Curcuma longa (turmeric), and whose various therapeutic effects, such as anti-inflammatory, antimicrobial, anticancer, and antioxidant properties have invited huge attraction over the past years. It has found much research due to its possible use in treating diseases like arthritis, cardiovascular diseases, diabetes and some neurodegenerative diseases. Notwithstanding its potential therapeutic properties, the clinical application of curcumin is deeply hampered by its low bioavailability systemically and low aqueous solubility.

Curcumin is fast metabolized and excreted hence its low serum levels during administration through traditional oral routes. Such low bioavailability limits its potential clinical application by impairing its potential to affect included sites in the body with the therapeutic effect. Also, curcumin is hydrophobic compound, thus, the issues of formulation and delivery are associated with the inability to reach adequate therapeutic effects.

1.2 Drawbacks of The Standard Pathways Owing to Low Bioavailability

Orally is the most popular method of delivery though many challenges are involved in the curiosity of oral route. Curcumin is poorly soluble in water and hence is poorly absorbed by the gastrointestinal tract and gives insufficient systemic levels when the drug is consumed. Its bioavailability is also further decreased in the liver as a large part of the drug is metabolized before reaching the systemic circulation through a process termed first- pass metabolism. These concerns propel the idea of looking into other possibilities of delivering the compound, in a manner to boost the bioavailability of the curcumin, and improve its capacity to treat.(1)

These challenges are not properly dissected by the use of conventional formulations, which include tablets, capsules, and liquid suspensions hence necessitating alternative strategies of drug delivery. Although injectable formulations have applications in therapeutic settings of immediate need, they are least applicable in chronic/long-term therapy and also in children and old members of the population who are prone to injection reactions.

1.3 The use of Nanocarriers and Transdermal Systems in the Drug Repository Enhancement

In order to escape the drawbacks of the classical delivery pathways, the nanocarriers including liposomes, micelles, and transfersomes have attracted a lot of attention within the scope of drug delivery research. These nanostructured carriers are able to enhance the solubility, stability and the bioavailability properties of such poorly water soluble compounds as curcumin. Specifically, transfersomes are elastic vesicles made up of phospholipids and surfactants, which are created to improve the amount of drugs penetration on biological barriers. Transfersomes are flexible

enough so as to deform and enter stratum corneum, through which they offer greater skin permeability and offer control of a drug release over time.

Also the transdermal routes of administration have become one of the promising means of delivering drugs that are not well absorbed through gastrointestinal tract. Skin represents a large surface area upon which drugs can be absorbed and transdermal systems can release drugs in a sustained manner in a non-invasive way hence overcoming patient non-compliance. With the use of transdermal systems in conjunction with nanocarriers, a drug such as curcumin can directly enter the bloodstream bypassing the gastrointestinal tract and first pass metabolism resulting into a considerable increase of their bioavailability and efficacy.(2)

1.4 Goal: The Development and Evaluation of a Transfersomal Gel Delivery of Curcumin to the Skin

In this study, the aim will be to produce and test a transfersomal gel form in curcumin delivery to the skin. Its scope is to increase the dermal uptake of curcumin with the help of transfersomal vesicles and make it easier on becoming a Carbopol 940 gel basis. Transferosomal gel system is aimed to demonstrate controlled release of curcumin to enhance its therapeutic efficiency and guarantee the long-term therapeutic effect. The sensitivity to skin penetration, patient compliance and stability of the formulation will also be optimized and each formulation should be such that a slow drug release is achieved and bioavailability is maximized. In this way, the research is aimed at solving the delivery shortcomings of the traditional curcumin formulations and providing a solution of a non-invasive and efficient form of a curcumin topical treatment.

The study of the variables that determine the quality of the drug release, the penetration into the skin and the presence or absence of irritation by carrying out an evaluation of the main biophysical parameters, will lead to a possible solution to the application of curcumin as a drug in case of chronic inflammation as well as other therapeutic uses of curcumin which needs to be delivered with high efficiency and high duration of use due to the strong nature of curcumin.

2. Materials and Methods

2.1 Formulation chemicals and Excipients

Substances employed during the preparation of curcumin-loaded transfersomal gel formed the following:

Curcumin (Curcuma longa): Sigma-Aldrich was used as the source of the active pharmaceutical ingredient (API). Curcumin, a drug that has weak water solvability, was selected due to the that has properties of anti-inflammatory and antioxidant.

Phosphatidylcholine: a principal phospholipid to form the lipid bilayer of the transfersomal vesicles. Lipoid GmbH was the source of Phosphatidylcholine used to give the structural development to the vesicles.

Tween 80 (Polysorbate 80): A non-ionic surfactant and as an emulsifying reagent, and promoter of transfersomal vesicles. It assists in reducing the surface tension and enhancing curcumin solubility. The surfactant was provided by Sigma-Aldrich.(3)

Cholesterol: Cholesterol is used as an excipient as it stabilizes the lipid bilayer by enhancing stability of the transfersomes. They got their cholesterol in Sigma-Aldrich.

Carbopol 940: It is a high molecular weight polymer that is used to constitute the gel base of the transfersomal system. Lubrizols,., Carbopol 940: Carbopol 940 was obtained; Gelation was employed in order to impart the required gelation property to the formulation i.e., such as its required viscosity and spreadability.

Distilled Water: It was used in the preparation of vesicular suspension as the solvent against which the dispersion of the excipients proceeded.

Ethanol: It has been employed in thin-film hydration method of preparing transfersomes. It was used as a solvent of the lipid film.

Glycerin: It is introduced to the gel formulation as a plasticizer to give desirable spreadability and hydration qualities.

2.2 Transfersome Hydration Thin-Film Method

To create the transfersomal vesicles, thin-film hydration method was followed as below:

Lipid film formation: Phosphatidylcholine mixed with cholesterol and Tween 80 in a certain proportions and dissolved in ethanol to form the mixture in round-bottom flask. Rotary evaporation on a reduced pressure at 40 o C was then carried out on the ethanol solution to form thin lipid film on the inner surface of the flask.

Film Hdration: Once the thin lipid film was achieved, then the flask was hydrated using an aqueous solution of curcumin in distilled water at a temperature of 50 o C. The gelling solution was given 1 hour to hydrate and this created transfersomal vesicles.

Sonication: The vesicular suspension made hydrated is sonicated by using a probe sonicator to disrupt the vesicles into nano sizes using a probe sonicator. The move assists in attaining the targeted particle size and the lipid bilayer stability.(4)

The obtained transfersomal suspension was subsequently filtered thereby recovering unencapsulated curcumin, which was later stored at 4 o C.

2.3 Transfersomal Vesicles Characterization

The physicochemical characteristics of the transfersomal vesicles were defined by the particle size, zeta potential, entrapment efficiency.

Particle Size and Zeta Potential: Malvern Zetasizer Nano was gravitated to an average particle size and zeta potential of the transfersomal vesicles. The size of the particle plays significant role in defining the ability of the vesicles to penetrate the skin and the zeta potential shows whether the vesicles are stable in suspension. Since the value of zeta potential (-32.1 mV) was negative, then it meant that the vesicles existed well dispersed in water and that repulsion force due to electrostatic effect existed between them.

Entrapment Efficiency: To find the entrapment efficiency of the curcumin in the transfersomal vesicles, the unentrapped curcumin was separated with the help of a centrifugation technique in which the technique was set at 15,000 rpm at 30 minutes. Curcumin content of the supernatant was measured with UV-Vis spectrophotometer at the absorption wavelength of the drug. The formula to calculate the entrapment efficiency was:

Entrapment Efficiency(%)=(Total DrugTotal Drug−Free Drug)×100

2.4 Inclusion in Carbopol 940 Gel Base

The transfersomal suspension was added to base gel of Carbopol 940 to make transfersomal gel. It had to be done as follows:

Gel Preparation: A 1% Gel Carbopol 940 gel was prepared by suspending the polymer in distilled water and left to swell over a period of 1hour. The gel was adjusted to pH 5.5-6.0 by the addition of 0.5% triethanolamine solution so that the ideal gelation could be obtained.

Introduction of Transfersomes: Transfersomal suspension was then added gradually to the gel base with the help of continuous stirring to provide a homogeneous distribution. The last gel was refrigerated at 4o C to make other analysis.95)

2.5 Physicochemical tests

A set of physicochemical tests was conducted on the developed transfersomal gel to obtain the appropriate physiochemical properties of the gel to make it pharmaceutically good and suitable in transdermal delivery.

Texture: The values of the texture parameter of the gel which include its spreadability, firmness and viscosity were determined with a texture analyzer. The gel should be spreadable such that it easily flows on the skin and it must also be firm such that when skin is applied, the gel does not spread aside.

release in vitro: released drug in vitro using Franz diffusion cell; the transfersomal gel formulation was tested for the drug release of the loaded molecules into the Franz cell. A membrane with a gel was inserted into an area with a donor, there was a buffer solution in a receptor area. The release of drugs was traced up to a period of 24 hours and the data obtained by the release analyzed to calculate the release kinetics.

Ex-Vivo skin permeation: Ex-vivo permeation study was conducted on the pig ear skin which is similar to humans. The gel was placed on the skin and the quantity of curcumin that was absorbed through the skin was checked and checked after some time. This paper assisted in finding out the flux, and penetration of the Transfersomal gel loaded with curcumin.

Primary Dermal Irritation Test in Dermal: This was a rabbit study to test the safety of the gel composition by conduct of a primary dermal irritation test. The gel was contacted to the dorsal skin of rabbits and it was monitored against erythema, edema, and other inflammation symptoms. Also, the formulation did not indicate any causes of irritations on the skin thus it is safe to be applied on the skin.

3. Formulation rationale Optimization

3.1 Vesicle forming agents and Surfactant selection

This kind of formulation of curcumin-loaded transfersomal gel is based on vesicle-forming concentration and surfactants, which have the potential to increase the transdermal transportability of curcumin which pitifully has low solvency and low permeability. These agents were chosen on the ground that they form stable vesicles and enhance the penetration of curcumin across the stratum corneum.(6)

The most appropriate vesicle forming agent was chosen as phosphatidylcholine (PC), which is a phospholipid due to its lipid bilayers forming capability, which gives structural and stability to transfersomes. PC also helps to encapsulate the lipophilic curcumin and also results in the sustainable delivery of the drug.

Non-ionic surfactant Tween 80 (Polysorbate 80) was selected in order to induce the synthesis of fluid and flexible transfersomes. This surfactant also aids in decreasing the surface tension of the lipid and aqueous phase and thus increases the stability and drug entrapment ability. It also enhances the ability of the skin penetration of the vesicles, which ensures that curcumin reaches the target site.

Cholesterol was added to stabilize the lipid bilayer and regulate the fluidity of the vesicles and so to increase the retention of the formulation on the skin to have controlled release of the drug.

3.2 Adjustment of Vesicle Size and Walls Diffusion Parameter

To attain the intended skin permeation and the drug releasing profile, optimization of vesicle size and entrapment efficiency played a key role. The size of the particle affects the capacity of vesicles to reach inside the skin and the small vesicles tend to cross the stratum corneum.

The average size of the transfersomal vesicles was adjusted to an optimum size of about 134.6 nm which having good skin penetration as well as being stable. Smaller vesicles are easier to deform them and fit them through the opening of the skin, enhancing the flux and permeation of curcumin.

Entrapping efficiency was also optimized in order to have a maximum loading of the drug without compromising the integrity of the vesicles. Having an entrapping efficiency of 92.4% the formulation also warrants an adamant amount of curcumin being encapsulated so as to infuse the most therapeutic effect and reduce wastage to minimum.

3.3 Reason to Select the Gel Base and to Determine the Spreadability

The gel base is an imperative determinant of transfersomal formulation application and release kinetics. Carbopol 940 gel base was used due to its viscosity aiding in the formulation so that it can be easily applied and have the right consistency to be used dermally. It gives a sustained release of the medication and makes sure that the formulation in its form does not break during application on the skin surface.(7)

Spreadability was done to make sure that there could be no difficulties in spreading the gel covering the skin, and it could not be too runny or too thick. Better patient compliance is possible due to suitable spreadability, which is particularly beneficial to a pediatric or elderly population that might not be able to apply the thick or cumbersome gels. This evaluation supported the optimal texture to be used topically and therapeutic effect.

4. Transfersomal Gel Transfersomal Gel Characterization and Evaluation

4.1 Stability, particle size and morphology characteristics

The size of particle of curcumin loaded transfersomal vesicles play a decisive role in the penetration of the skin and stability of the vesicles. The vesicles were calculated to have an average particle size of 134.6 nm which is good in delivering through the skin. The smaller the size of the vesicles the deformability and penetration through skin pores is enhanced and thus the absorption ability of the drugs is attained effectively. It is also a size that guarantees big surface area of drug release which guarantees prolonged delivery.

The transfersomal vesicles morphology was also detected in scanning electron microscopy (SEM). The SEM images showed the smooth surface of the vesicles and their apportionment was square without aggregation. Such homogeneity is necessary to achieve regular drug liberation and stability. These vesicles were observed to be flexible and deformable which are the properties of transfersomes and thus, went through the skin with low resistance.

The physical inspection of the vesicles or their physical appearance was measured, distribution of particles and zeta potential was measured at every 2 weeks up to 3 months. There was also no major variations in size and aggregation of the vesicles, suggesting that the formulation was stable after prolonged periods of use. The vesicles were characterized in terms of zeta potential; a value of −32.1 mV could be detected, which implies that the dispersion was stable, because the negatively charged surface of the vesicles hinders aggregation of the vesicles, therefore increasing the dispersion stability.(8)

4.2 Entrapment Efficiency and Zeta Potential Readings

Entrapping effectiveness of the curcumin filled transfersomal vesicles was calculated to assess the degree of the curcumin sequestration in the vesicles. Vesicles exhibited high level of entrapping efficiency, that is 92.4% demonstrating that, maximum therapeutic effect was obtained by the incorporation of the major percentage of curcumin in the form of a vesicular structure. It is imperative to achieve high entrapping efficiency so that sustained and steady release of drugs is achieved that can effectively prolong therapeutic effects of curcumin

And the zeta potential was also determined to determine the halting and dispersion characteristics of transferred vesicles. The stability of the vesicles used was also realized by the presence of zeta potential of about -32.1 mV; this is because the negative charge repels the vesicles and therefore makes the resulting of the gel base appear evenly distributed. The dispersion stability is good as suggested by the negative zeta potential and is important to maintain consistency in drug delivery and lack of instability during store.(9)

4.3 Texture Profile (Firmness, Adhesiveness, Spreadability)

A texture analyzer was utilized to measure the significant rheological measurements including firmness, adhesiveness and spreadability of the transfersomal gel.

Firmness is the ability of the gel not to deform and it was observed to be suitable to be applied on the skin whereby it was firm enough to hold on the skin but yet can be applied without difficulty.

One of the requirements needed is adhesiveness, which will make the gel stick to the skin without sliding out. The force necessary to lift the gel off the skin surface was used to measure the adhesiveness and the gel was found to be competent with good adhesiveness with no skin irritation hence, the adhesiveness can be used to deliver the drug by transdermal delivery method.

The process of spreadability was evaluated through determining how easily the gel spread across the skin. The gel had high spreadability properties and thus can be spread on the skin easily and uniformly which improves the treatment compliance and its efficacy in patients.

4.4 Modeling of Release Kinetics and Mechanism In-Vitro

In-vitro drug release was carried out to determine the release profile of curcumin transfersomal gel in 24 hours by using the Franz diffusion cell apparatus. The release study was conducted in phosphate buffer (pH 7.4) which represents the conditions of the skin. The tests indicated that gradual release of curcumin was observed, and 85% of the drugs had been released throughout 24 hours.

In order to represent the release mechanism, a number of kinetics were fitted to the release data such that; zero-order, first-order and Higuchi were used. Releasing of the drug by the gel was also of Higuchi model which implied that the drug release occurred mainly by diffusion through the transfersomal vesicles. This release vehicle makes sure that curcumin is given in a slow dose to present therapeutic levels to the body in a prolonged time frame.

The findings indicate that transfersomal gel formulation provides controlled drug release that is imperative in enhancing therapeutic efficacy of curcumin and lessen the application frequency. The formulation has been optimised to allow a controlled and long term delivery of curcumin through the skin, which increases the bioavailability and compliance in patients.(10)

5. The Safety and Permeation of the Skin

5.1 Ex-Vivo Skin Permeation Ex vivo through pig ear skin

The ex-vivo permeation experiment was performed to measure the permeability of the curcumin-loaded transfersomal gel in penetrating through the pig ear skin, which is usually taken as a model to the human skin because of the similarity in terms of structure and composition. The permeation was conducted in the Franz diffusion cell apparatus whose gel was applied to the stratum corneum side of the pig ear skin, whereas the receptor chamber was filled with phosphate buffer solution (pH 7.4) in order to mimic the skin.

Skin permeability of curcumin was determined by measuring total curcumin permeations at different time points (i.e., up to 24 hours). The findings were that the transfersomal gel gave a better curcumin permeation than the conventional ones. It is probably because the transfersomes are elastic and deformable, and as such, the vesicles can more easily penetrate the stratum corneum and, therefore, subsequently deliver curcumin more effectively to the deeper regions of the skin. The flux was greatly increased using the transfersomal gel determining improved ability of transfersomal gel in skin delivery of curcumin in comparison to other traditional formulations.

5.2 Flux Comparative Analysis Versus Traditional Curcumin Gel

To gain additional information of the efficacy of the transfersomal gel, a comparative analysis of flux of transfersomal gel was undertaken with a typical curcumin gel. The control gel was used by mere dissolving curcumin in a conventional Carbopol 940 gel base without incorporating any nanocarriers.

The findings showed that the transfersomal gel had a drastically increased curcumin flux through the skin as compared to the conventional gel. Although limited skin penetration of curcumin was demonstrated in the conventional gel because of low solubility in medicine and the lack of the carrier to deepen permeation in the skin, the transfersomal gel released a greater amount of curcumin during 24 hours. This augmented flow may be explained by the accommodative character of the transfersomes that are flexible and elastic and enable effective penetration of the skin and the extended drug-delivery. That makes the transfersomal gel a more effective and promising solution of transdermal delivery of curcumin with increased therapeutic potential.(11)

5.3 Results of Animal Model: Dermal Irritation Test

To determine the skin safety of the curcumin-loaded transfersomal gel, a dermal irritation test to rabbits was done to conduct safety assessment. The gel was salved on the dorsal skin of the rabbit at the duration of 24 hours and study was performed on the skin to check any sign of irritation such as-erythema (redness), edema (swelling) or other indicator of inflammation.

The test findings indicated the absence of any visible skin irritation or adverse reactions toward the tested transfersomal gel. There was no redness, swelling, and inflammation at the point of application, and the skin was normal 24 hours after application. This indicates that topical application of the formulation is safe and will not cause skin irritation and thus can be used in a clinical setting in the long term as well.

5.4 Topical Use of Formulations Suitability Evaluation

Topical suitability of the transfersomal gel On the basis of results of permeation, flux studies, and dermal irritation tests, the transfersomal gel was found to be suitable to be used topically. Gelolized was found capable of significantly increasing skin permeation of curcumin relative to conventional gels, and it released the drug through a 24-hour period. The safety and tolerability of the formulation was also established by the fact that; there was no skin irritation in the animal model.(12)

The flexibility, hardness of the gel, and its ability to hold to the skin was able to meet these requirements and would be best suited in the dermal application, whereby there is easy and comfortable application as well as more than satisfactory retention of the gel to the skin so that the drug maybe delivered over an extended period. Based on the positive outcomes of these tests, the formulation seems to be a comfortable and efficient system of the delivery of topical curcumin, which provides the increased therapeutic utility and better bioavailability.

6. Results

The findings of the experiment of curcumin-loaded transfersomal gel can be concluded by the following ways:

Particle Size: a particle size average of the transfersomal vesicles was determined as 134.6 nm due to this the ease of penetration into the skin was achieved to increase the performance of transdermal delivery.

Entrapment Efficiency: The 92.4% ENTRAPMENT efficiency has meant that much of the curcumin was effectively entrap within the transfersomal vesicles to afford a sustained release and regulated drug delivery.

In-Vitro Drug Release: The in-vitro release analysis demonstrated prolonged release of the drug curcumin over 24 hours and this implies that a single application of drugs through the gel formulation can have a sustained therapeutic effect.

Skin Permeation: The skin permeation test proved that transfersomal gel showed a 2.8-folds higher permeation rate than that of the plain curcumin gel, proving the transfersomal formulation to be effective in enhancing and improving curcumin permeation through the skin.(13)

These results validated that transdermal delivery of curcumin and its therapeutic impact was greatly increased by the transfersomal gel shear, thus it is an emerging alternative to topical curcumin.

Table 1: Key Results Summary

Outcome Measure	Observation	Performance Metric
Particle Size	134.6 nm	Average size of vesicles
Entrapment Efficiency	92.4%	Percentage of curcumin encapsulated
In-vitro Drug Release	Sustained over 24 hours	Duration of release
Skin Permeation	2.8-fold higher compared to plain gel	Flux compared to plain gel

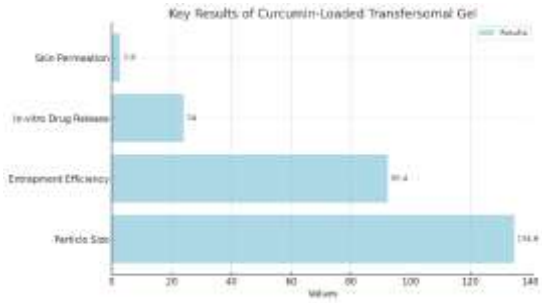

Figure 1: Key Results Of Curcumin-Loaded Transfersomal Gel

7. Conclusion

7.1 There is Significant Transdermal Curcumin Enhancement with Transfersomal Gel System

The transfersomal gel formulation prepared in this study has shown significant contributions to ameliorate the transdermal delivery of curcumin which is an anti-inflammatory and antioxidant material and is associated with hindered bioavailability and low skin permeability. The formulation using transfersomes as the skin penetrating vehicles resulted in enhanced drug flux more than the conventional Curcumin gel due to the elasticity of transfersomes. The size of the transfersomal vesicles (average size 134.6 nm) allowed the enhanced percutaneous penetration of the transfersomal system which is important in penetrating the deeper skin layers to obtain therapeutically effective levels of drugs.

The ex-vivo skin permeation study using pig ear skin showed that transfersomal gel produced a 2.8-folds higher skin permeation of curcumin than plain gel indicating that transfersomes elasticity and deformability was instrumental in increasing skin absorption. Acute and sustained release of curcumin 24 hours also proves the possibility of the transfersomal system to assure prolonged therapeutics, without need of frequent applications, which is quite beneficial in such treatment of chronic ailments.

7.2 Shows a Consistent Account of Physicochemical and Skin Health Characteristic

The determination of physicochemical character of the transfersomal gel ascertained the stability and the topical application of the gel. The entrapment efficiency of the formulation was found to be 92.4%, which means that a sizeable proportion of the curcumin has been able to be confined in between the transfersomal vesicles, hence, the drug has been effectively delivered. Zeta potential of -32.1mV was an indication of good dispersion stability of vesicles and they would not aggregate in storage and application. This will make sure that the formulation it makes will be effective and consistent in time.

More so, the dermal irritation experiment on rabbits revealed that the gel formulation could not invoke any indication of skin irritation or irritation and therefore can be used safely on skin. The gel can be applied without complications; it does not lump up and it is not sticky because of its appropriate spreadability, firmness and adhesiveness. All these results emphasize the physicochemical stability and the safety of the formulation, which renders it a perfect choice in terms of topical application.

7.3 Has a Prospect to Active Anti-Inflammatory Topical treatment

The overall result of the transfersomal gel, that is, the increase in skin permeation and sustained release and safety profile also indicate that it has the potential of being a viable form of topical anti-inflammatory agent. Curcumin is known to having anti-inflammatory effects, and this compound may be directly targeted to the region of swelling, e.g. arthritis, dermatitis, or muscles and bones. Transdermal administration of curcumin, which neither has to pass the gastrointestinal tract nor shows any side effects of curcumin in the body system, will markedly increase the local-treatment action of the drug as well as higher bioavailability of the drug.

The transfersomal gel system is also non-invasive and patient friendly way of delivering curcumin as an alternative to either oral or injection route of administration especially in chronic inflammatory diseases. The length of time that the gel retains drug release is long, and this aspect facilitates in maintaining a good level of curcumin to guarantee therapeutic action as a form of treatment that can be implemented every day by the patient due to the continuity in the treatment.

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Conflicts of interest

The authors have no conflicts of interest to declare

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