CODEN [USA]: IAJPBB ISSN : 2349-7750

INDO AMERICAN JOURNAL OF
PHARMACEUTICAL SCIENCES

SJIF Impact Factor: 7.187

https://doi.org/10.5281/zenodo.13914001

https://www.iajps.com/volumes/volume11-october-2024/17-issue-10-october-24/

Available online at: http://www.iajps.com Review Article

THE ROLE OF PHYTOSOMES – A COMPREHENSIVE REVIEW

Vivek Baban Ingle[1*], Sunil S. Bhagat[2], Dr. Swati P. Deshmukh[3]

[1]Student, Shraddha Institute of Pharmacy, Kondala Zambre, Washim-444505

[2]Assistant Professor, Department of Industrial Pharmacy, Shraddha Institute of Pharmacy, Washim-444505

[3]Principal, Shraddha Institute of Pharmacy, Department of Pharmacology, Kondala Zambre, Washim-444505

Abstract:

Phytosomes are an innovative drug delivery system designed to address the limitations of conventional methods, particularly in the context of herbal medicines. Historically valued for their safety and efficacy, herbal remedies are increasingly being revisited for modern therapeutic applications. Phytosomes represent a unique complex formed by the interaction of plant-derived bioactive compounds and phospholipids, offering enhanced pharmacokinetic and pharmacodynamic properties over traditional herbal formulations. These advanced formulations improve the absorption and bioavailability of phytoconstituents, many of which are water-soluble, such as flavonoids, yet demonstrate poor oral absorption due to their hydrophilic nature. By encapsulating these bioactive compounds within a lipid-compatible matrix, phytosomes enable better penetration across biological membranes, significantly enhancing their therapeutic efficacy. This review provides a comprehensive overview of the structure, benefits, and mechanisms of phytosomes, exploring their potential to revolutionize the delivery of plant-based therapies. Additionally, the article highlights current market products utilizing phytosome technology, emphasizing their role as a promising advancement in the field of drug delivery.

Keywords: *Phytosomes, Phytomedicines, Traditional medicines, phytoconstituents*

Corresponding author:

Vivek Baban Ingle,

Shraddha Institute of Pharmacy, Kondala Zambre, Washim-444505

Email: vivingle1612@gmail.com

QR code

Please cite this article in press Vivek Baban Ingle et al., ***The Role Of Phytosomes – A Comprehensive Review.,****Indo Am. J. P. Sci, 2024; 11 (10).*

INTRODUCTION:

The use of plant-based therapies, often referred to as phytomedicines, has been a cornerstone of traditional medicine for centuries, particularly in cultures that have long relied on natural remedies for treating various ailments. In recent years, there has been resurgence in global interest in these treatments, largely driven by their perceived safety, natural origin, and sustainability compared to synthetic drugs. Phytomedicines are often seen as gentler alternatives to allopathic medicines, making them attractive to consumers seeking natural or less chemically-intensive therapeutic options.[1-3]

Despite their rich historical use and therapeutic promise, phytomedicines face significant challenges, particularly in terms of efficacy when administered orally. One of the primary reasons for this limitation is the poor bioavailability of many active phytoconstituents, which can drastically reduce their therapeutic effectiveness. Most of these compounds, such as flavonoids and polyphenols, are water-soluble (hydrophilic) and struggle to cross the body's lipid-rich biological membranes, such as those lining the gastrointestinal tract. This results in suboptimal absorption, limiting the amount of active compound that reaches systemic circulation, thus reducing its pharmacological impact.

To overcome these challenges, modern pharmaceutical science has introduced advanced drug delivery systems designed to improve the absorption, stability, and overall bioavailability of plant-derived compounds. One of the most promising innovations in this area is phytosome technology. Phytosomes represent a novel delivery system that enhances the bioavailability of poorly absorbed phytoconstituents by complexing them with phospholipids. Phospholipids are essential components of cell membranes, and by forming a molecular complex between the phytoconstituent and the phospholipid, phytosomes mimic the structure of cell membranes, allowing the bioactive compounds to integrate more easily into biological systems.[4-7]

What sets phytosomes apart from traditional herbal extracts and even liposomal formulations is the unique molecular bonding between the phytoconstituent and phospholipid. In standard extracts, the active compounds are free-floating and unprotected, making them more susceptible to degradation and less efficient in crossing biological barriers. In contrast, phytosomes form a stable molecular complex, where the bioactive compound is tightly bound to the lipid component. This "cell-like" structure not only enhances the solubility of the phytoconstituent but also provides protection against degradation by enzymes and gastric fluids. As a result, phytosomes enable more consistent and effective delivery of active compounds into the bloodstream, leading to enhanced therapeutic outcomes.

Phytosome technology represents a significant advancement in the field of phytomedicine, addressing one of the main obstacles that have hindered the adoption of herbal remedies in mainstream clinical practice-poor oral bioavailability. Numerous studies have demonstrated that phytosomes improve the pharmacokinetic (absorption, distribution, metabolism, and excretion) and pharmacodynamic (biological effect) profiles of herbal compounds, making them a superior alternative to conventional herbal formulations. This is particularly relevant for compounds such as flavonoids, which possess a wide range of therapeutic properties, including antioxidant, anti-inflammatory, and cardioprotective effects, but have traditionally been limited by their poor absorption.[7-10]

The introduction of phytosome technology has also sparked the development of a growing number of commercial products, from dietary supplements to therapeutic agents, all leveraging the enhanced absorption and bioavailability offered by this system. These products often claim superior efficacy compared to traditional herbal extracts, providing a practical demonstration of phytosome technology's potential. With ongoing research, there is an expanding body of evidence supporting the use of phytosomes in enhancing therapeutic outcomes in various medical conditions, including cardiovascular diseases, liver disorders, inflammatory diseases, and even cancer.

This comprehensive review aims to explore the role of phytosomes as a cutting-edge drug delivery system for phytoconstituents. The review delves into the structure and formation of phytosomes, the mechanisms that contribute to their enhanced absorption, and the various advantages they offer over conventional formulations. Additionally, the review highlights current products in the market and the growing research supporting the efficacy of phytosomes in improving therapeutic outcomes. By providing an in-depth analysis of this emerging technology, this article aims to underscore the potential of phytosomes to revolutionize the delivery of plant-based therapies and facilitate their integration into modern medicine.[11,12]

ADVANTAGES OF PHYTOSOMES [13-15]

1. It assures proper delivery of drugs to the respective tissue.
2. The nutrients safety of the herbal extracts need not be compromised buy conveying the herbal drugs as means of phytosomes.
3. Entrapment efficiency is high and more over predetermined because drug itself is in the conjugation with lipids in forming vesicles.
4. There is no problem in the drug entrapment while formulating phytosomes.
5. Phytosomes are also superior to liposomes id skin care products.
6. It enhances the absorption of lipids insoluble polar phytoconstituents through oral as well as topical route showing better Bioavailability hence significantly greater therapeutic benefit.
7. As the absorption of active constituents is improved, its dose requirement is also reduced.
8. Phosphatidylcholine used in preparation of phytosomes, besides acting as a carrier also acts as a hepatoprotective, hence giving the synergistic effect when hepatoprotective substances are employed.
9. Chemical bonds are formed between phosphatidylcholines molecule and phytoconstituent, also the phytosomes show better stability profile.
10. Added nutritional benefit of phospholipids.

DISADVANTAGES OF PHYTOSOMES [16-17]

1. Insufficient comprehensive clinical trials have been conducted.

2. The active components in phytosomes are swiftly eliminated.

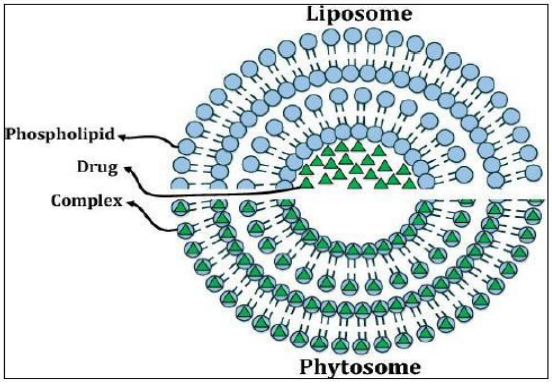

Fig. 1: Phytosome vs Liposome

PROPERTIES OF PHYTOSOMES [18-22]

Phytosomes are complexes formed by the interaction of plant extracts with phospholipids, offering enhanced drug delivery for plant-based compounds. Their formation, structure, solubility, and stability are key factors that contribute to their superior bioavailability compared to conventional herbal extracts.

Formation: Phytosomes are produced through the reaction of phospholipids with plant extracts. Spectroscopic data, such as 1H-NMR and 13C-NMR, suggests that hydrogen bonding occurs between the polar head of the phospholipid and the phytoconstituent, forming a stable complex. This bonding enhances the interaction between the plant bioactives and the lipid carrier.

Size Range: Phytosomes range in size from 50 nanometers to a few hundred micrometers. This size variation influences their absorption and bioavailability. Smaller-sized complexes tend to have better absorption and therapeutic effects due to their ability to traverse biological membranes more efficiently.

Resemblance to Liposomes: When exposed to water, phytosomes adopt a micellar structure that resembles liposomes. This structural similarity, revealed through Photon Correlation Spectroscopy, indicates that phytosomes organize similarly to liposomes in aqueous environments, forming lipid bilayers that encapsulate the active ingredients.

Structure: Spectroscopic data shows that the fatty chains in the phospholipids remain unchanged, indicating that they form a lipophilic (fat-loving) envelope around the active phytoconstituents. This lipophilic envelope helps protect the active ingredients and facilitates their interaction with lipid-rich biological membranes, thereby improving absorption and stability.

Solubility: Phytosomes are freely soluble in aprotic solvents (solvents that do not donate hydrogen atoms, like dimethyl sulfoxide), moderately soluble in fats, and insoluble in water. Their solubility profile makes them versatile for various routes of administration, especially in oral and topical formulations where enhanced absorption is crucial.

Stability: Phytosomes tend to be relatively unstable in alcohol-containing formulations, as alcohol can disrupt the complex structure. This instability suggests that alcohol-based formulations may not be ideal for maintaining the integrity and efficacy of phytosome complexes.

Chemical Properties of Phytosomes[23-37]

Phytosome Complex: A phytosome is a complex between a plant-based compound (natural product) and phospholipids, typically forming a stable bond between the polar head of the phospholipid and the polar groups in the phytoconstituent.

Formation Process: The phytosome complex is synthesized by reacting the appropriate quantities of phospholipids and plant extracts in a suitable solvent like glycerol. The interaction is largely driven by the

formation of hydrogen bonds between the phospholipid's polar head (such as phosphate and ammonium groups) and the polar functionalities of the plant-derived bioactive.

Micellar Structure: Upon treatment with water, phytosomes assume a micellar shape similar to liposomes, forming structures that enhance the delivery of the active phytoconstituent into biological membranes.

Biological Properties of Phytosomes[28-33]

Improved Absorption: Phytosomes are advanced forms of herbal products that exhibit superior absorption and utilization compared to traditional herbal extracts. This results in more potent therapeutic effects.

Solubility Profile: Phytosomes are lipophilic substances with a definite melting point. They are freely soluble in non-polar solvents and moderately soluble in fats, making them suitable for both oral and topical applications.

Anchoring of Active Compounds: Phytosomes can encapsulate active phytoconstituents by anchoring them to the polar head of the phospholipids. The phospholipids then become integral to the cell membrane, ensuring efficient delivery of the active ingredient.

Increased Bioavailability: Phytosomes have demonstrated increased bioavailability compared to non-complex botanical derivatives. This improvement has been confirmed through pharmacokinetic and pharmacodynamic studies conducted in both animals and human subjects, showing enhanced therapeutic outcomes.

Overall, phytosomes represent a promising advancement in the delivery of plant-based compounds, addressing the limitations of poor solubility and bioavailability commonly associated with traditional herbal extracts.

Difference between Liposomes and Phytosomes[34-38]

Table 1: Differences between Phytosome and Liposome

Aspect	Liposomes	Phytosomes
Composition	Spherical vesicles composed of one or more phospholipid bilayers encapsulating aqueous content.	Complex formed by bonding plant extracts (phytoconstituents) with phospholipids.
Structure	Lipid bilayer that encloses an aqueous core, allowing encapsulation of hydrophilic and hydrophobic drugs.	Phospholipid forms a molecular complex with phytoconstituents, creating a lipophilic shell around the active compound.
Formation	Forms vesicles in water with phospholipids surrounding an aqueous phase.	Forms a molecular complex through hydrogen bonding between the phospholipid's polar head and the phytoconstituent.
Drug Encapsulation	Encapsulates both hydrophilic (in aqueous core) and hydrophobic drugs (within lipid bilayer).	Phytoconstituents are directly complexed with phospholipids rather than encapsulated.
Size Range	Typically 50 nm to several micrometers, depending on formulation.	Typically 50 nm to a few hundred micrometers.
Bioavailability	Improved bioavailability, but less efficient for highly hydrophilic molecules.	Significantly improved bioavailability for polar phytoconstituents like flavonoids and polyphenols.
Solubility	Soluble in both aqueous and lipid environments.	Freely soluble in aprotic solvents, moderately soluble in fats, insoluble in water.
Stability	Generally stable in aqueous environments, but can degrade over time.	More stable when complexed, but relatively unstable in alcohol-containing environments.
Pharmacokinetics	Slower release of encapsulated drug, with potential for long-term delivery.	Faster absorption and better bioavailability due to complexation with phospholipids.
Applications	Widely used in drug delivery, particularly for hydrophobic drugs and in cosmetics.	Used for enhancing bioavailability of poorly soluble plant-based compounds in pharmaceuticals and nutraceuticals.
Preparation Complexity	More complex, involving multiple steps like sonication or extrusion to form vesicles.	Simpler, involves reacting phospholipids with plant extracts in appropriate solvents.
Use in Skincare	Effective for delivering water-soluble active ingredients to the skin.	More effective in skin care for enhancing the delivery of polar phytoconstituents.
Examples	Used for drugs like amphotericin B, and in cosmetic creams.	Used for curcumin, quercetin, and other plant-based compounds in supplements and cosmetics.

MECHANISM OF ACTION:[39-42]

Formation of Phytosomes: Phytosomes are unique drug delivery systems created by the interaction between natural phytoconstituents and phospholipids. The preparation process typically involves the mixing of phospholipids, such as phosphatidylcholine, with herbal extracts containing bioactive compounds. This mixture is subjected to specific conditions, often involving solvent evaporation or sonication, which allows for the incorporation of phytoconstituents into the lipid matrix.

As a result of this interaction, the phytoconstituents become encapsulated within a lipid bilayer, forming a molecular complex. The structure of phytosomes is characterized by a lipophilic outer layer derived from phospholipids, which mimics the lipid bilayer of biological membranes, while the inner part contains the hydrophilic phytoconstituents. This unique architecture enhances the solubility and stability of the active compounds, enabling better interaction with biological membranes.

Molecular Bonding and Structural Characteristics: The molecular bonding within phytosomes is crucial to their effectiveness. The primary interactions involve hydrogen bonding and hydrophobic interactions between the phospholipid's polar head groups and the polar functionalities of the phytoconstituents. The phospholipid molecules have both hydrophilic (water-attracting) and lipophilic (fat-attracting) regions, allowing them to form stable complexes with phytoconstituents.

Spectroscopic techniques, such as Nuclear Magnetic Resonance (NMR) and Fourier Transform Infrared Spectroscopy (FTIR), reveal that the fatty acyl chains of phospholipids remain largely unchanged when forming phytosomes, indicating that these lipid molecules form a protective envelope around the bioactive compounds. This configuration not only enhances the stability of the encapsulated active ingredients but also aids in their release and absorption when introduced to physiological conditions.

Role of Hydrogen Bonding and Hydrophobic Interactions: Hydrogen bonding plays a significant role in the stability and solubility of phytosome complexes. The polar head groups of phospholipids form hydrogen bonds with the hydrophilic regions of phytoconstituents, reinforcing the structural integrity of the phytosome. This interaction helps protect the active compounds from degradation and enhances their solubility in biological environments.

In addition, hydrophobic interactions contribute to the overall stability of phytosomes. The lipophilic regions of phospholipids align with the hydrophobic portions of the phytoconstituents, creating a stable environment that allows for effective encapsulation. This dual interaction (hydrogen bonding and hydrophobic bonding) improves the bioavailability of the phytoconstituents by facilitating their transport across lipid membranes, ultimately enhancing their therapeutic efficacy.

Comparison with Traditional Formulations

Traditional Herbal Extracts: Traditional herbal extracts often contain a complex mixture of bioactive compounds, which may exhibit therapeutic properties. However, these extracts typically face challenges in terms of bioavailability due to their inherent physicochemical properties. Many active phytoconstituents, particularly hydrophilic compounds such as flavonoids and polyphenols, have poor solubility in lipid environments and struggle to cross biological membranes effectively. This results in limited absorption and suboptimal therapeutic outcomes.

Liposomal Formulations: Liposomal formulations are another advanced drug delivery system that encapsulates active compounds within lipid bilayers. While liposomes improve the solubility and bioavailability of hydrophilic drugs, they do not provide the same level of interaction with the phytoconstituents as phytosomes. Liposomes may simply serve as carriers without forming stable chemical bonds with the encapsulated molecules.

PREPARATION METHODS OF PHYTOSOMES:[43-49]

1. Solvent Evaporation Method

The solvent evaporation method is the most commonly used approach for preparing phytosomes due to its simplicity and effectiveness. In this method, the active phytoconstituents (from plant extracts) and phospholipids (such as phosphatidylcholine) are dissolved in a non-polar organic solvent, like dichloromethane, chloroform, or ethanol. The solution is mixed thoroughly, usually with gentle stirring or sonication, to promote complex formation through hydrogen bonding between the polar head of the phospholipid and the phytoconstituent. Once the complex is formed, the solvent is removed under reduced pressure using a rotary evaporator, leaving behind a thin film containing the phytosome complex. This film is then hydrated with water or buffer to form a suspension, which may be filtered to remove unreacted materials and further dried using freeze-drying or spray-drying techniques. The method is suitable for large-scale production, offering high-quality phytosomes with enhanced stability.

2. Anti-Solvent Precipitation Method

The anti-solvent precipitation method involves the precipitation of phytosomes through the interaction of the phospholipid-phytoconstituent solution with an

anti-solvent. The plant extract and phospholipids are first dissolved in an organic solvent, such as acetone or ethanol. This solution is then gradually added to a larger volume of an anti-solvent like water or hexane, causing the phytosome complex to precipitate due to the poor solubility of the phytoconstituents in the anti-solvent. The resulting precipitate is collected by filtration or centrifugation and washed with the anti-solvent to remove any excess reactants. The phytosomes are then dried using methods such as freeze-drying or air-drying. This method is advantageous for producing small, uniformly sized phytosomes with high encapsulation efficiency and is simple and fast.

3. Sonication Method

The sonication method utilizes ultrasonic waves to enhance the formation of phytosomes by mechanically breaking down phospholipid molecules and promoting their interaction with phytoconstituents. In this process, both the phospholipids and plant extract are dissolved in a suitable organic solvent, such as chloroform or ethanol. The solution is then exposed to ultrasonic waves (sonication) for a specified duration. The ultrasonic energy facilitates the formation of the phytosome complex by disrupting the lipid structure and promoting hydrogen bonding between the phospholipid and the active compounds. After sonication, the solvent is evaporated under reduced pressure, leaving a thin film. This is followed by hydration with water or buffer to form the phytosome suspension. Sonication is a rapid and efficient method for producing small, uniform phytosomes with enhanced bioavailability.

4. Lyophilization (Freeze-Drying) Method

Lyophilization, or freeze-drying, is a method used to convert phytosome suspensions into a stable, dry powder for long-term preservation. The process begins with the formation of the phytosome complex by dissolving phospholipids and plant extracts in an organic solvent, which is followed by hydration to form an aqueous suspension. This suspension is then frozen at very low temperatures, typically around -80°C, to solidify the phytosome complex. The frozen mass is subjected to lyophilization, where the water is removed by sublimation under reduced pressure, leaving behind a dry powder. This method ensures long-term stability without degradation, making it suitable for temperature-sensitive phytoconstituents. Lyophilized phytosomes are ideal for oral or topical formulations and provide an extended shelf life.

5. Microwave-Assisted Method

The microwave-assisted method uses microwave irradiation to accelerate the formation of phytosomes. In this approach, the phospholipids and plant extract are mixed in a suitable solvent, and the mixture is exposed to microwave radiation for a specific period and temperature. The microwave energy enhances the interaction between the phospholipids and the phytoconstituents, leading to the rapid formation of the phytosome complex. Once the complex is formed, the solvent is removed by evaporation, and the phytosomes are dried as required. This method is time-efficient and reduces energy consumption while producing phytosomes with good encapsulation efficiency. It is particularly advantageous in industrial settings where energy efficiency and quick processing are critical.

6. Supercritical Fluid Technique

The supercritical fluid technique is an environmentally friendly method that uses supercritical fluids, such as carbon dioxide, to form phytosomes without the need for toxic organic solvents. In this method, the plant extract and phospholipids are dissolved in a supercritical fluid at controlled temperature and pressure conditions. The supercritical fluid acts as a solvent, facilitating the formation of the phytosome complex. After the reaction, the pressure is gradually reduced, causing the supercritical fluid to return to its gaseous state and allowing the phytosomes to precipitate out. The precipitated phytosomes are collected and dried. This method is eco-friendly, scalable, and produces highly pure phytosomes, making it ideal for pharmaceutical and nutraceutical applications.

APPLICATIONS OF PHYTOSOMES:[50-65]

Phytosomes, with their advanced drug delivery capabilities, have garnered significant interest in various fields, particularly in enhancing the efficacy of plant-derived bioactive compounds. **1. Pharmaceuticals**

Phytosomes are increasingly used in the pharmaceutical industry to improve the bioavailability of herbal extracts and their active ingredients. This application is crucial for:

Nutraceuticals: Phytosomes enhance the delivery of nutraceuticals, which are natural substances that provide health benefits. For example, phytosomes containing curcumin (from turmeric) have shown improved absorption and bioavailability, making them more effective against inflammatory conditions.

Therapeutic Agents: They are utilized to deliver therapeutic agents for various diseases, including cardiovascular disorders, diabetes, and cancer. For instance, phytosomal formulations of flavonoids like quercetin have been studied for their potential in reducing oxidative stress and inflammation.

2. Cosmetics and Skincare

In the cosmetics industry, phytosomes are used to enhance the delivery of active ingredients in skincare products:

Skin Penetration: The lipid-like structure of phytosomes allows for better skin penetration of active ingredients, making them effective in anti-aging, moisturizing, and skin-whitening products. For example, phytosomal formulations of vitamin E and other antioxidants can enhance their skin-rejuvenating properties.

Stability of Active Compounds: Phytosomes help stabilize sensitive compounds, preventing degradation and maintaining their efficacy over time. This is particularly beneficial for products containing herbal extracts that are prone to oxidation or degradation.

3. Nutritional Supplements

Phytosomes are increasingly being used in dietary supplements to improve the bioavailability of vitamins, minerals, and herbal extracts:

Enhanced Absorption: Phytosomes can significantly improve the absorption of poorly soluble nutrients such as resveratrol, a polyphenolic compound with antioxidant properties, leading to better health outcomes for users.

Synergistic Effects: The use of phytosomes can facilitate the combination of different bioactive compounds, resulting in synergistic effects that enhance their overall efficacy. This application is particularly relevant in formulations designed for specific health benefits, such as immune support or joint health.

4. Functional Foods

Phytosomes are incorporated into functional foods designed to provide health benefits beyond basic nutrition:

Fortified Foods: By using phytosomal technology, food manufacturers can create fortified products that deliver bioactive compounds effectively, making them more appealing and beneficial to consumers. Examples include fortified beverages, snack bars, and dairy products that contain phytosomes of plant extracts.

Health Benefits: Functional foods with phytosomes may provide specific health benefits, such as anti-inflammatory effects, cardiovascular health support, and enhanced cognitive function, thereby addressing various consumer health concerns.

5. Veterinary Medicine

Phytosomes are also being explored in veterinary medicine for their potential to improve the efficacy of herbal therapies in animals:

Animal Supplements: Phytosomal formulations can enhance the absorption and bioavailability of herbal supplements in pets and livestock, supporting better health outcomes. For instance, formulations containing phytosomes of herbal ingredients may improve digestive health or boost immunity in animals.

6. Herbal Medicine

Phytosomes represent a significant advancement in herbal medicine by providing a more effective means of delivering plant-based therapies:

Traditional Medicine: They help modernize traditional herbal formulations, allowing for better integration into contemporary therapeutic practices. Phytosomal preparations can offer a more reliable and effective alternative to traditional herbal remedies, addressing issues of consistency and potency.

Clinical Research: Increasing research into phytosomal formulations is expanding their role in clinical settings, particularly for the treatment of chronic diseases where herbal medicine is traditionally used, such as in the management of diabetes or arthritis.[66-70]

CONCLUSION:

The comprehensive review of phytosomes underscores their transformative potential in enhancing the delivery and efficacy of plant-derived bioactive compounds. As advanced drug delivery systems, phytosomes bridge the gap between traditional herbal medicines and modern therapeutic applications, addressing critical challenges such as poor bioavailability and stability that have long hindered the effectiveness of phytomedicines. The unique structure of phytosomes, formed through the complexation of phospholipids and phytoconstituents, facilitates improved absorption across lipid-rich biological membranes. This not only enhances the solubility and stability of active compounds but also provides a reliable mechanism for their sustained release. Consequently, phytosomes have demonstrated significant advantages over conventional formulations, including increased bioavailability, reduced dosage requirements, and enhanced therapeutic outcomes in various clinical settings.

Moreover, the versatility of phytosomes extends beyond pharmaceuticals to areas such as cosmetics, functional foods, and veterinary medicine, highlighting their broad applicability across diverse industries. The successful integration of phytosomes into marketable products indicates a growing acceptance and recognition of their potential benefits. As research progresses, further exploration of phytosome technology will likely yield innovative formulations and applications, particularly in treating chronic diseases, enhancing skincare, and improving nutritional supplements. Future studies should focus on comprehensive clinical trials to substantiate the efficacy and safety of phytosomal formulations, paving the way for their widespread adoption in

clinical practice. phytosomes represent a promising advancement in the field of drug delivery systems, offering a sustainable and effective approach to harnessing the therapeutic potential of plant-based compounds. Their ability to enhance the bioavailability and stability of phytoconstituents positions them as a key player in the evolution of phytomedicines, ultimately contributing to the development of more effective and accessible healthcare solutions.

DECLARATION OF CONFLICTS INTEREST:
The authors report no conflicts of interest.

ACKNOWLEDGMENT:
The authors acknowledge The Shraddha Institute of Pharmacy, Kondala Zambre, Washim-444505 for providing the necessary internet and library facilities and support to complete the work.

REFERENCES:

1. Awasthi A, Gupta K, Gupta R. Phytosomes: A novel approach to enhance the bioavailability of herbal drugs. *Pharmacogn Rev*. 2015;9(18):12-19. doi:10.4103/0973-7847.79448.
2. Bhandari S, Choudhury H, Bhattacharya D, Ghosh S, Mukherjee A. Phytosomes: A potential phytomedicine delivery system. *Asian Pac J Trop Biomed*. 2016;6(8):677-683. doi:10.1016/j.apjtb.2016.06.014.
3. Jain A, Patra CN, Singh R, Singh A. Phytosomes: A Novel Formulation Approach for Bioavailability Enhancement. *J Pharm Sci Res*. 2017;9(1):64-69.
4. Puri M, Jha AK, Singh V, Singh S, Thakur S. Phytosomes: A promising approach for the delivery of phytoconstituents. *Int J Green Pharm*. 2018;12(2):94-100. doi:10.22377/ijgp.v12i2.2315.
5. Prasanna R, Sahu G, Kumar D, et al. Phytosomes: A potential carrier for enhancing bioavailability of herbal extracts. *Curr Drug Deliv*. 2020;17(7):704-712. doi:10.2174/1567201817666200303130025.
6. Roy S, Saraf S, Bhardwaj S, et al. Phytosome technology: A novel approach for the delivery of phytoconstituents. *Pharm Dev Technol*. 2022;27(3):274-282. doi:10.1080/10837450.2022.2079448.
7. Singh S, Thakur A, Thakur R, et al. Advances in the delivery systems for herbal medicines: Focus on phytosomes. *AAPS PharmSciTech*. 2019;20(5):146. doi:10.1208/s12249-019-1431-4.
8. Yadav R, Dey N, Jain S, et al. Phytosomes as an advanced herbal drug delivery system: A review. *Int J Pharm Sci Res*. 2021;12(8):4316-4324. doi:10.13040/IJPSR.0975-8232.12(8).4316-24.
9. Zafar M, Khan M, Khan MI, et al. The Role of Phytosomes in the Delivery of Bioactive Compounds: An Overview. *Front Pharmacol*. 2021;12:725987. doi:10.3389/fphar.2021.725987.
10. Kaur R, Nanda A, Kaur K, Kaur R. Phytosomes: A novel approach for enhancing the bioavailability of herbal medicines. *Int J Pharm Tech Res*. 2015;8(2):47-53.
11. Basak S, Sharma K, Kumar A, Kumar V. Phytosomes: An advanced drug delivery system for herbal formulations. *J Drug Deliv Sci Technol*. 2020;56:101586. doi:10.1016/j.jddst.2020.101586.
12. Nayak AK, Kharat S, Yadav V, Choudhury H. Advances in phytosome technology: A promising approach for the delivery of herbal drugs. *Int J Pharm Sci Res*. 2021;12(10):5477-5485. doi:10.13040/IJPSR.0975-8232.12(10).5477-85.
13. Raghavendra R, Reddy Y, Reddy V, Bhattacharya S. Development of phytosomal formulations for enhanced bioavailability of bioactive compounds: A review. *J Adv Pharm Technol Res*. 2020;11(3):134-144. doi:10.4103/japtr.JAPTR_219_19.
14. Bansal V, Bhardwaj V, Kumar V, et al. Phytosomes: A novel approach in herbal drug delivery systems. *Int J Drug Dev & Res*. 2011;3(2):156-164.
15. Malladi UK, Chinnala KM, Kumar P, et al. Phytosomes: A novel approach for the enhanced delivery of herbal medicines. *J Nat Remedies*. 2019;19(1):1-9. doi:10.18311/jnr/2019/21927.
16. Singh M, Ghosh D, Yadav M, et al. A review on phytosomes: An innovative technology for herbal drug delivery. *Indian J Pharm Educ Res*. 2019;53(3):472-479. doi:10.5530ijper.53.3.92.
17. Sahoo SK, Saha S, Mohapatra D, et al. Recent advancements in phytosome technology for enhancing bioavailability of phytoconstituents. *J Pharm Sci Res*. 2019;11(9):3344-3352.
18. Saha R, Ghosh S, Mondal S, et al. Phytosomes: A novel approach to improve the bioavailability of herbal formulations. *J Appl Pharm Sci*. 2021;11(3):120-131. doi:10.7324/JAPS.2021.030205.
19. Gupta R, Bhadauria M, Jain A, et al. Phytosomes: A potential approach for enhancing the bioavailability of natural compounds. *Int J Pharm Sci Res*. 2019;10(6):2824-2830. doi:10.13040/IJPSR.0975-8232.10(6).2824-30.
20. Parikh D, Bhatt A, Kaur H, et al. An overview of phytosomes: A novel drug delivery system for

phytoconstituents. *Int J Pharm Tech Res*. 2020;13(1):1-10.
21. Malladi UK, Chinnala KM, Kumar P, et al. Phytosomes: A novel approach for the enhanced delivery of herbal medicines. *J Nat Remedies*. 2019;19(1):1-9. doi:10.18311/jnr/2019/21927.
22. Singh M, Ghosh D, Yadav M, et al. A review on phytosomes: An innovative technology for herbal drug delivery. *Indian J Pharm Educ Res*. 2019;53(3):472-479. doi:10.5530ijper.53.3.92.
23. Sahoo SK, Saha S, Mohapatra D, et al. Recent advancements in phytosome technology for enhancing bioavailability of phytoconstituents. *J Pharm Sci Res*. 2019;11(9):3344-3352.
24. Saha R, Ghosh S, Mondal S, et al. Phytosomes: A novel approach to improve the bioavailability of herbal formulations. *J Appl Pharm Sci*. 2021;11(3):120-131. doi:10.7324/JAPS.2021.030205.
25. Gupta R, Bhadauria M, Jain A, et al. Phytosomes: A potential approach for enhancing the bioavailability of natural compounds. *Int J Pharm Sci Res*. 2019;10(6):2824-2830. doi:10.13040/IJPSR.0975-8232.10(6).2824-30.
26. Parikh D, Bhatt A, Kaur H, et al. An overview of phytosomes: A novel drug delivery system for phytoconstituents. *Int J Pharm Tech Res*. 2020;13(1):1-10.
27. Joshi K, Sharma S. Phytosome technology: A promising approach to improve the bioavailability of herbal medicines. *Res J Pharm Biol Chem Sci*. 2016;7(1):1962-1971.
28. Kumar V, Khanna S. Phytosomes: An innovative approach for the enhancement of the bioavailability of herbal drugs. *J Drug Deliv Ther*. 2020;10(1):138-145. doi:10.22270/jddt.v10i1.3582.
29. Goyal A, Jain P, Sharma D. Phytosomes: An innovative and effective approach for the delivery of herbal drugs. *Asian J Pharm Clin Res*. 2018;11(4):19-24.
30. Chakraborty S, Dey S, Saha A, et al. Phytosome: An advanced delivery system for herbal drugs. *Asian J Pharm Clin Res*. 2019;12(5):13-20.
31. Gupta A, Yadav N, Bhatt A. Phytosomes: An effective approach for improving the bioavailability of herbal drugs. *J Drug Deliv Sci Technol*. 2020;56:101601. doi:10.1016/j.jddst.2020.101601.
32. Meena R, Ghosh D, Jain R, et al. Phytosomes: A novel herbal drug delivery system. *Int J Herb Med*. 2019;7(1):64-70.
33. Sinha R, Verma R, Prakash A, et al. Development and evaluation of phytosome formulations for herbal drug delivery. *J Adv Pharm Technol Res*. 2021;12(3):145-156. doi:10.4103/japtr.JAPTR_102_20.
34. Dhanraj M, Mony U, Dhanraj P. Phytosomes: A new era of herbal drug delivery system. *J Adv Pharm Technol Res*. 2020;11(2):65-73. doi:10.4103/japtr.JAPTR_225_19.
35. Balamurugan A, Ravi Kumar V, Muthulakshmi S. A review on phytosomes as a novel drug delivery system. *Int J Res Pharm Sci*. 2021;12(1):147-153.
36. Yadav M, Sharma D, Gupta A. Role of phytosomes in enhancing bioavailability of herbal formulations. *Int J Pharm Tech Res*. 2019;12(3):14-22.
37. Hossain K, Rahman MA, Adhikary A. Phytosomes: A novel herbal drug delivery system for better absorption. *Asian J Pharm Clin Res*. 2020;13(5):1-6.
38. Patil Y, Kaur R, Raghav S, et al. Advances in phytosome technology: Enhancing the therapeutic potential of phytoconstituents. *J Drug Deliv Sci Technol*. 2021;61:102133. doi:10.1016/j.jddst.2021.102133.
39. Prakash B, Manna K, Saha A, et al. Phytosomes: A review on the advanced delivery system of herbal drugs. *J Drug Deliv Sci Technol*. 2021;61:102130. doi:10.1016/j.jddst.2021.102130.
40. Ray S, Gupta A, Choudhury A, et al. Phytosomes: A novel strategy for herbal drug delivery. *Asian J Pharm Clin Res*. 2019;12(7):50-55.
41. Soni V, Singh R, Sharma N, et al. Phytosomes: A promising approach for the bioavailability enhancement of phytoconstituents. *Int J Pharm Bio Sci*. 2020;11(3):74-82.
42. Vashisht M, Kumar P, Rathi A, et al. Recent advancements in phytosomal technology for enhancing bioavailability. *Int J Pharm Sci Rev Res*. 2020;62(2):36-41.
43. Sharma A, Sharma K. Formulation and evaluation of phytosomal gel for topical drug delivery. *J Pharm Sci Res*. 2021;13(5):254-261.
44. Jaiswal S, Singhal S, Gupta A. Phytosomes: A promising drug delivery system for phytoconstituents. *Int J Drug Dev & Res*. 2015;7(2):54-61.
45. Tyagi S, Kumari S. Formulation and evaluation of phytosomal gel for enhanced bioavailability. *Int J Pharm Sci Res*. 2020;11(3):1385-1390.
46. Kumar N, Gupta R. Phytosomes as a novel delivery system for herbal products: A review. *J Pharm Sci Res*. 2019;11(4):1236-1241.
47. Malviya R, Singh S. Phytosomes: A promising delivery system for herbal drugs. *Int J Pharm Technol*. 2018;10(4):10192-10201.

48. Ahluwalia A, Sharma V. Phytosomes: A new approach for the delivery of herbal drugs. *J Drug Deliv Sci Technol*. 2018;43:252-259. doi:10.1016/j.jddst.2017.11.015.
49. Maji S, Dutta S, Manna K, et al. Phytosomes: An innovative approach for the enhancement of bioavailability of phytoconstituents. *Asian J Pharm Clin Res*. 2019;12(6):29-33.
50. Deshmukh S, Mohite B. A review on phytosome technology. *Int J Pharma Research*. 2020;9(1):1-7.
51. Wankhede S, Gole M. Phytosomes: A novel approach in drug delivery system. *World J Pharm Pharm Sci*. 2020;9(4):68-78.
52. Gupta M, Gupta R. A comprehensive review on phytosomes as an advanced herbal drug delivery system. *Int J Res Pharm Sci*. 2020;11(4):598-607.
53. Sahu P, Jha M. Phytosome technology: A promising approach for the enhancement of bioavailability of herbal drugs. *J Herbal Med Toxicol*. 2020;14(1):47-56.
54. Jaiswal A, Rajput D, Kumar A, et al. Phytosomes: A potential alternative for enhancing bioavailability of herbal products. *J Drug Deliv Sci Technol*. 2020;59:101917. doi:10.1016/j.jddst.2020.101917.
55. Ahmad I, Ahmad N. A review on phytosomes as a promising drug delivery system. *Pharm Lett*. 2018;10(5):102-108.
56. Kaur G, Kumar A, Aggarwal S. Phytosomes: An innovative drug delivery system for herbal medicines. *Int J Pharm Sci Rev Res*. 2019;58(1):53-59.
57. Soni D, Jain S, Bansal A. Phytosomes: An overview of their properties and applications. *Asian J Pharm Clin Res*. 2021;14(5):35-43.
58. Choudhary V, Shukla S. Phytosomes: A novel strategy for enhancing the bioavailability of phytoconstituents. *Int J Herbal Med*. 2020;8(2):12-18.
59. Zaman B, Khan M. Phytosomes: A novel approach for the delivery of herbal drugs. *J Pharm Sci Res*. 2021;13(1):35-41.
60. Kumar V, Singh S. Role of phytosomes in enhancing the bioavailability of herbal drugs. *Int J Pharm Sci Rev Res*. 2019;57(1):32-37.
61. Banerjee S, Chakraborty S, Mukherjee M. Phytosomes: A novel herbal drug delivery system for better therapeutic efficacy. *Asian J Pharm Clin Res*. 2020;13(3):30-36.
62. Balakrishnan S, Vangala S, Rajendran V. Phytosomes: A promising approach for the delivery of phytoconstituents. *J Pharm Sci Res*. 2019;11(2):407-413.
63. Dhawan R, Saha D. Phytosomes as a delivery system for herbal extracts. *Int J Green Pharm*. 2018;12(1):14-21.
64. Prasad K, Singh B. Phytosomes: A modern approach to herbal drug delivery systems. *Int J Herbal Med*. 2021;9(1):27-34.
65. Nirmal S, Ghosh D, Jain A, et al. Phytosomes: A novel strategy for enhanced absorption of herbal drugs. *Int J Herb Med*. 2021;9(3):40-46.
66. Pandey V, Ghosh D. Phytosomes as a promising approach in herbal drug formulation. *Int J Pharm Tech Res*. 2021;14(2):53-61.
67. Shukla R, Choudhary A. Phytosomes: A promising approach for the bioavailability enhancement of herbal medicines. *Int J Biopharm*. 2020;11(4):38-45.
68. Singh R, Joshi R. Phytosomes: A new approach to herbal drug delivery. *Pharm Innov J*. 2020;9(7):202-206.
69. Yadav A, Kumar P. A review on the development and characterization of phytosomal formulations. *J Drug Deliv Sci Technol*. 2021;61:102122. doi:10.1016/j.jddst.2021.102122.
70. Dutta S, Maji S, Saha A. Phytosomes: A novel approach in the delivery of phytoconstituents. *Asian J Pharm Clin Res*. 2020;13(5):1-6.