

REVIEW article

Revolutionizing herbal medicine delivery through phytosome technology

Verma Anju¹  , Kumari Saumya¹  , Kumari Anjali¹  , and Sonar P. Kumar^{2*}  

¹Department of Pharmaceutical Science and Technology, Madan Mohan Malaviya University of Technology, Gorakhpur, India

²Government Pharmacy College, B.R.D. Medical College Campus, Gorakhpur, Uttar Pradesh, India

* Author to whom correspondence should be addressed

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Abstract: Herbal medicines have been extensively used for centuries owing to their therapeutic benefits and comparatively low incidence of adverse effects. Despite their clinical potential, the effectiveness of many herbal formulations is limited by poor aqueous and lipid solubility, low bioavailability, rapid metabolism, and inadequate absorption across biological membranes. Phytosome technology has emerged as an advanced drug delivery strategy designed to overcome limitations by enhancing the pharmacokinetic and pharmacodynamic performance of plant-derived bioactive compounds. Phytosomes are lipid-based molecular complexes formed through the interaction of phytoconstituents with phospholipids, resulting in improved stability, membrane permeability, and systemic absorption. This approach facilitates efficient transport of active constituents across biological barriers, leading to enhanced therapeutic efficacy compared with conventional herbal extracts. The amphiphilic nature of phospholipids enables improved solubility in both aqueous and lipid environments while simultaneously acting as a biocompatible carrier that promotes cellular uptake and bioactivity. Phytosome formulations have demonstrated significant success in delivering poorly absorbed phytochemicals such as flavonoids, polyphenols, and terpenoids, showing improved outcomes in the management of inflammation, liver disorders, cardiovascular diseases, metabolic conditions, and cancer. Additional advantages include reduced dosage requirements, sustained drug release, enhanced patient compliance, and minimized side effects. Overall, phytosome technology represents a significant advancement in herbal drug delivery, effectively integrating traditional herbal medicine with modern pharmaceutical science. Its capacity to improve bioavailability and therapeutic performance positions phytosomes as a promising platform for the future development of safe, effective, and standardized natural product-based therapeutics.

Introduction

Since ancient times, herbal remedies have been utilized to cure a wide range of illnesses [1-3]. However, bioavailability, the body's capacity to absorb and use these plant compounds, remains one of their main obstacles. The efficiency of many herbal actives, such as flavonoids and polyphenols, is severely limited since they are water-soluble and poorly absorbed through our cells' lipid-rich membranes [4]. To get around this, researchers created phytosomes, a brand-new medicine delivery method that envelops herbal compounds in phospholipids, making it easier for them to pass through cell membranes and travel to their intended location within the body. These act as small protective vesicles that safeguard herbal compounds during digestion and enhance their absorption into the bloodstream [5, 6]. In contrast to conventional extracts, phytosomes enhance the stability of plant active ingredients and increase their therapeutic benefits by forming chemical interactions

with them. Numerous well-known herbs, including green tea for its antioxidant properties, *Ginkgo biloba* for brain health, and *Silybum marianum* for liver support, have benefited from this technology. According to clinical research, these phytosomal versions perform noticeably better than conventional herbal treatments [7]. The adaptability of phytosomes, which can be utilized in topical, oral, and even cosmetic formulations, makes herbal remedies more effective and widely available. They are used to cure liver disease, lower oxidative stress, or improve skin health. Phytosomes represent a smart fusion of nature and science that brings out the full potential of plant-based therapies [8, 9]. The term phytosome means "plant" and "some" means "cell"; it is a novel drug delivery system. Herbal medicines have likely existed for as long as humanity. At present, a majority of the global population relies on phytomedicines for healthcare [10, 11]. Herbal medications are widely used in the modern world because they can treat a wide range of illnesses with effective therapeutic outcomes and minimal toxicity. Plants, along with their phytoconstituents and pharmacological effects, possess significant medicinal value and benefit human health [12]. But despite various benefits of herbal medicine, it cannot be used widely because drug levels below the therapeutic concentration in the plasma can result in fewer or no therapeutic effects due to certain limits of herbal medicines and phytochemicals, such as instability in extremely acidic pH, pre-systemic metabolism in the liver, and solubility and absorption issues [13-15]. Additionally, the majority of plant actives, including glycosides, tannins, flavonoids, and others, are polar molecules with poor absorption because of their large molecular size, which restricts absorption through passive diffusion, and poor lipid solubility, which significantly reduces their capacity to pass through biological membranes that are rich in lipids result in decreased plant actives' bioavailability and, thus, their low therapeutic index [16]. By reducing presystemic metabolism, drug degradation in the gastrointestinal tract, and drug distribution/accumulation in non-targeted tissues and organs, the use of innovative drug delivery technology in plant actives lowers side effects, increases therapeutic efficacy, and eventually improves patient compliance [17]. Using innovative drug delivery systems to distribute herbal medications, the novel drug delivery method for herbal remedies should be able to deliver the active ingredient to the site of action at a rate dictated by the body's needs and the chronopharmacology of the disease over the course of treatment. Several Novel Drug Delivery Systems that have been combined with phytochemicals and herbal medications can be broadly divided into the following categories: Vesicular delivery mechanisms, such as transferosomes, erthosomes, phytosomes, and liposomes (**Table 1**) [18].

Table 1: Emerging "somes" and their applications with description [16]

Vesicular system	Description	Application
Aquasomes	These are circular 60-300 nm fundamental particles used for drug as well as antigen delivery. They have a three-layered self-assembly structure with a ceramic or carbon nanocrystalline core coated with glassy cellobiose.	Specific targeting, molecular shielding
Archaeosomes	Vesicles made of glycerolipids derived from archaea have effective auxiliary action.	Poor adjuvant activity
Colloidosomes	Solidified microcapsules formed by self-assembly of colloidal particles at emulsion droplet interfaces; flexible shells with controllable permeability.	Drug targeting
Cryptosomes	Lipid vesicles with a surface layer of PC and polyoxyethylene derivatives from phosphatidyl ethanolamine.	Ligand-mediated drug delivery
Carbohydrosome	Composed of methyl-2,3-di-O-lauroyl-β-D-ribose-5 phosphocholine (DLRPC); novel vesicular structures made from carbohydrate-based lipids (zwitterionic, cationic, or anionic).	Biological targeting of macromolecules or ligands
Cubosomes	Bicontinuous cubic phase structures with two non-intersecting hydrophilic domains separated by a lipid bilayer arranged in a periodic minimal surface.	Drug targeting
Discosomes	Niosomes associated with non-ionic surfactants.	Ligand-mediated drug targeting
Emulsomes	Nano-sized lipid particles consisting of a lipid core and a polar outer layer.	Parenteral delivery of poorly water-soluble drugs
Enzymosomes	Liposomes with enzymes covalently attached to their surface.	Targeted delivery to tumor cells

Erythroosomes	Liposomal systems linked to human erythrocyte cytoskeletons with a lipid bilayer coating.	Targeting of macromolecular drugs
Ethosomes	Soft, flexible lipid vesicles composed of phospholipids, ethanol, and water act as permeation enhancers.	Targeted delivery to deep skin layers
Escheriosome	Lipoidal vesicles made from polar lipids extracted from <i>Escherichia coli</i> .	Drug targeting
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Particle-based drug delivery systems such as microspheres, nanoparticles, and micropellets, along with biphasic systems like microemulsions and nanoemulsions, enhance drug stability and bioavailability [19]. Phytoconstituents present in herbal extracts may be either water-soluble or lipid-soluble; however, most are predominantly water-soluble. Their absorption is often limited due to several factors. First, being water-soluble, they have poor affinity for the lipid-rich phospholipid bilayer of biological membranes, resulting in low permeability. Second, the presence of multiple ring structures in their chemical composition can hinder membrane passage. Third, their relatively large molecular size restricts diffusion across membranes via simple passive diffusion in conventional drug delivery systems [20].

Historical background: Phytosome technology was introduced in 1989 by Franco Bombardelli and colleagues to enhance the bioavailability of polyphenolic compounds, which are typically poorly absorbed when administered orally [20]. Italian researchers discovered that certain polyphenols in plant tissues exhibit a strong affinity for phospholipids. Based on this finding, they developed phytosomes, molecular complexes formed by the interaction of polyphenols with phospholipids, primarily phosphatidylcholine (PC), and a key component of cell membranes. The unique structure of phytosomes enhances the solubility and absorption of polyphenols, thereby improving their bioavailability and overall therapeutic efficacy. Comparative studies have demonstrated that polyphenols in phytosome form exhibit superior clinical efficacy compared to their non-phytosome counterparts. This innovative technology significantly enhances the therapeutic potential of plant polyphenols, making them more effective for various health applications [21, 22]. Phytosomes protect herbal constituents from intestinal degradation, thereby improving their absorption and overall bioavailability. PC not only acts as a carrier but also provides additional therapeutic benefits, particularly in liver protection. Phytosome technology has been successfully applied to several herbal extracts, including ginseng, milk thistle, *Ginkgo biloba*, and green tea. In this system, phytoconstituents interact with the choline head of PC to form a stable, microsphere-like structure, ultimately enhancing their efficacy [23].

Phytosomes technology: Phytosomes, also known as phytolipid delivery systems, bridge the gap between conventional and novel drug delivery approaches. These innovative vesicular systems are designed to deliver drugs more efficiently to the target site and release them in a controlled manner according to physiological requirements [23]. The development of such advanced delivery systems has enabled site-specific and controlled drug release through various administration routes, thereby improving therapeutic outcomes [24, 25]. PC, the key component of phytosomes, plays a major role in this protective effect due to its gastro-protective properties [26]. The major limitation of water-soluble phytoconstituents is their poor absorption and low bioavailability, which restricts their effectiveness as therapeutic agents [27]. Several approaches have been employed to overcome this limitation, including encapsulation of these compounds in lipophilic carriers, structural modification, and the use of solubility and bioavailability enhancers. Among these, phytosome technology represents a significant advancement, as it converts water-soluble phytoconstituents, particularly polyphenols, into lipid-compatible molecular complexes, thereby improving their absorption and bioavailability [28]. These advantages give phytosomes superior pharmacological and pharmacokinetic properties, making them perfect for the treatment of acute diseases. In addition to pharmaceuticals, they are utilized in cosmetic compositions where enhanced bioavailability is crucial for effectiveness [29]. Phytosomes are prepared by counterstaining a standardized extract with a stoichiometric amount of PC in a nonpolar solvent. PC, commonly derived from soybeans, possesses a dual nature: its hydrophilic choline head interacts with water-soluble phytoconstituents to form a stable complex, while its lipophilic phosphatidyl tail facilitates integration with lipid membranes, thereby enhancing absorption [30]. Phospholipids form a molecular complex that is compatible with lipids and referred to as phytolipid complexes. The polar choline head of the phospholipids and molecules are bonded through chemical bonds. The phytosome technology produces small structures, in which the plant concentrates safeguard from ruination by gastric secretions and gut bacteria attributable to the gastroprotective property of PC [31].

Phytosomes vs liposomes: Phytosomes and liposomes are phospholipid-based drug delivery systems designed to improve the bioavailability of bioactive compounds, but they differ in structural organization and drug-phospholipid interaction. Phytosomes are molecular complexes formed by chemical interaction between plant bioactive constituents, particularly flavonoids or polyphenols, and phospholipids such as PC, usually in a 1:1 or 2: 1 ratio. In phytosomes, hydrogen bonding occurs between the polar groups of phytoconstituents and the phosphate and ammonium groups of phospholipids, resulting in a lipid-compatible complex that resembles biological membranes and enhances membrane permeability, gastrointestinal absorption, and systemic bioavailability of poorly lipid-soluble phytochemicals. Phytosomes are commonly prepared in solvents with low dielectric constants and have been successfully applied to herbal extracts such as ginseng, milk thistle, hawthorn, grape seed, Ginkgo biloba, and green tea, thereby improving therapeutic efficiency and pharmacokinetic performance [26, 28, 30, 32-34]. In contrast, liposomes are vesicular systems composed of phospholipid bilayers that encapsulate bioactive compounds without forming specific chemical bonds with them. The drug remains physically entrapped within an aqueous core or associated with the lipid bilayer, preserving chemical integrity while enabling controlled drug release, improved distribution, and reduced toxicity. Liposomes are spherical, biodegradable vesicles ranging from about 0.05-5.0 μm and are widely used in pharmaceutical applications, particularly for anticancer drug delivery, where they enhance drug accumulation at tumour sites while minimizing exposure to healthy tissues [35-38]. Thus, phytosomes enhance herbal drug delivery through chemical complex formation, whereas liposomes function primarily as physical encapsulation carriers for targeted and controlled drug delivery (**Figure 1**) [38].

Advantages: Phytosomes enhance the oral and topical absorption of lipid-insoluble and polar phytoconstituents, thereby significantly improving their bioavailability and therapeutic efficacy. Drug entrapment within delivery systems such as hydrogels, liposomes, or nanoparticles ensures efficient incorporation of active compounds, enabling controlled drug release, enhanced bioavailability, and reduced toxicity [10]. Improved absorption of active constituents further allows a reduction in the required therapeutic

dose. PC, a key component of phytosome formulations, performs a dual function as both a carrier and a hepatoprotective agent, contributing synergistically to liver protection and improved therapeutic outcomes when combined with hepatoprotective phytoconstituents [39]. The formation of specific chemical interactions between PC molecules and phytoconstituents imparts greater physicochemical stability to phytosomes compared to conventional systems. Phospholipids also provide multiple nutritional benefits, including support for brain health through maintenance of cell membrane integrity and cognitive function, improvement of liver detoxification and prevention of fatty liver disease, promotion of cardiovascular health via cholesterol metabolism, enhancement of gut health through improved fat emulsification and nutrient absorption, anti-inflammatory and immune-supportive effects, and preservation of cellular membrane fluidity and functionality. These essential dietary components naturally occur in foods such as eggs, soy, fish, and dairy products. Phytosomes additionally improve percutaneous absorption of phytoconstituents, making them highly useful in dermatological and cosmetic applications by enhancing skin health and anti-aging effects [40]. The phytosome structure forms microscopic complexes that protect herbal constituents from degradation by gastrointestinal enzymes and gut microflora, thereby preserving biological activity. Moreover, phytosomes enhance the bioavailability of hepatoprotective flavonoids, increasing their pharmacological effectiveness [41]. Due to strong chemical interactions between PC and phytoconstituents, phytosomes exhibit superior stability compared to liposomes and enable formulation of stable emulsions or creams by improving the solubility of poorly water-soluble compounds [42]. Overall, phytosomes represent advanced drug delivery systems that enhance membrane permeability, cellular uptake, stability, and drug entrapment while allowing controlled and sustained drug release, making them a promising strategy for targeted delivery of phytochemicals with improved therapeutic efficacy [43].

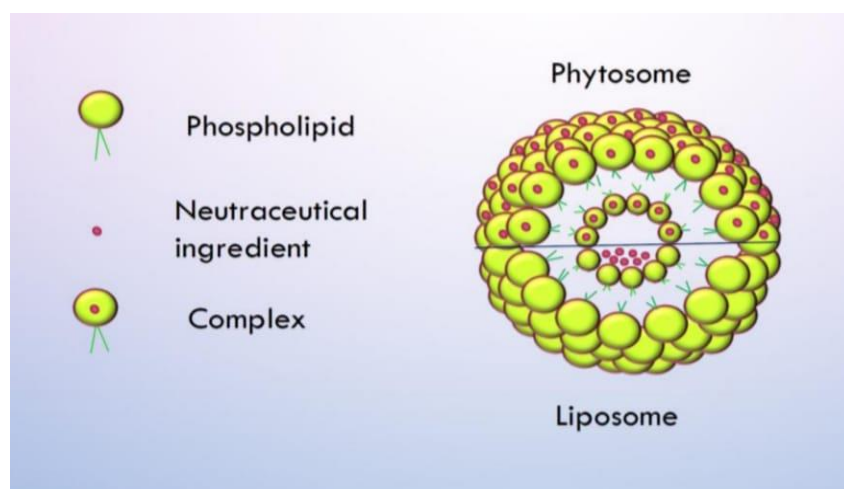


Figure 1: Major difference between liposome and phytosome [39]

Methods of preparation: Phytosome technology is designed to form small, cell-like structures that protect plant extracts or active ingredients from degradation by gastric fluids and intestinal microflora [39]. The main component responsible for this protective process is PC, which has gastro-protective qualities. Because phenolics, glycosides, and flavonoids are the majority of the bioactive ingredients in phytomedicines, which are water-soluble, their efficacy is frequently compromised by inadequate absorption when applied topically or consumed orally [39]. Water-soluble phytoconstituents' main drawback is their poor bioavailability and absorption, which limits their potential as medicinal agents. Several strategies have been used to get around this problem, such as trapping these chemicals in lipophilic carriers, structural alterations, and the use of solubility and bioavailability enhancers. This technology offers a significant advancement by converting water-soluble phytoconstituents, particularly polyphenols, into lipid-compatible molecular complexes. This transformation markedly enhances their absorption and facilitates efficient transport to target tissues, resulting in improved clinical efficacy without compromising safety. Because of these benefits, phytosomes have better

pharmacological and pharmacokinetic characteristics, which make them ideal for treating acute illnesses. Additionally, they are used in cosmetic formulations, where improved bioavailability is essential for efficacy, in addition to medications [45]. By treating a standardized extract with a stoichiometric quantity of PC in a non-polar solvent, phytosomes are created. The dual nature of PC, which is often obtained from soybeans, is that its hydrophilic choline group combines with water-soluble components to form a stable compound, while its lipophilic phosphatidyl portion forms the tail. Phospholipids form a molecular complex that is compatible with lipid and referred to as the Phytolipid complex [46]. The polar choline head of the phospholipids and molecules are bonded through chemical bonds. This technology produces small structures, in which the plant concentrates safeguard from ruination by gastric secretions and gut bacteria attributable to the gastroprotective property of PC [47].

Applications: Most plant bioactive constituents are predominantly water-soluble; however, their large molecular size and poor lipid solubility often limit membrane permeability and consequently reduce bioavailability. During isolation and purification processes, the natural synergistic interaction among phytochemicals may be disrupted, resulting in diminished or even complete loss of biological activity. Furthermore, oral administration may lead to degradation of sensitive phytoconstituents within the gastrointestinal tract, further decreasing therapeutic effectiveness. The chemical complexity of crude or partially purified plant extracts, therefore, plays an essential role in maintaining pharmacological activity and bioavailability. Phytosome technology, a patented drug delivery approach, overcomes these limitations by forming molecular complexes between phospholipids, particularly PC, and water-soluble phytoconstituents or standardized plant extracts. Unlike liposomes, which merely encapsulate active compounds, phytosomes establish a definite chemical interaction between PC and plant constituents in a 1:1 or 2:1 ratio, enhancing affinity toward biological membranes and improving absorption through increased membrane contact. Phospholipids further contribute by facilitating digestion and acting as natural carriers for both hydrophilic and lipophilic nutrients, thereby significantly enhancing systemic availability compared with conventional herbal preparations [48-50]. Phytosome technology has demonstrated wide pharmaceutical applications across many plant-derived therapeutics. Silymarin phytosomes prepared from *Silybum marianum* (milk thistle) exhibit improved lipophilicity and significantly enhanced bioavailability of silybin in experimental models, along with stronger anti-hepatotoxic activity and protection against aflatoxin B1-induced toxicity compared with free silymarin [51, 52]. Curcumin phytosomes developed using bioactive components such as naringenin (*Vitis vinifera*) and curcumin (*Curcuma longa*) showed markedly higher antioxidant activity and prolonged duration of action due to reduced elimination from the body. Similarly, quercetin-phospholipid phytosome complexes prepared through reproducible methods demonstrated superior therapeutic efficacy over quercetin alone in carbon tetrachloride-induced liver injury models [15, 51]. Grape seed phytosomes containing proanthocyanidins complexed with phospholipids exhibit potent antioxidant and cardioprotective effects, including reduced aortic plaque formation in animal studies and enhanced antioxidant capacity in humans, indicating improved absorption and clinical effectiveness [53, 54]. Furthermore, phytosomes of *Ginkgo biloba* have shown two to four-fold higher bioavailability than conventional extracts, improved therapeutic outcomes in vascular disorders, better tolerability, and additional bronchoconstriction inhibitory activity, collectively demonstrating enhanced efficacy and absorption characteristics [55-59]. These findings highlight phytosomes as an advanced and promising strategy for improving the delivery, stability, and therapeutic performance of plant-derived bioactive compounds.

Techniques for evaluation

Spectroscopic techniques: Transmission electron microscopy (TEM) and scanning electron microscopy (SEM) are widely employed for the morphological characterization of phytosomes. TEM analysis provides high-resolution images that allow visualization of drug distribution within the phospholipid matrix and accurate determination of particle size. TEM micrographs of soybean-based phytosomes typically reveal

spherical vesicular structures with rough surfaces, uniform morphology, and absence of aggregation, indicating successful complex formation. In contrast, SEM is primarily used to evaluate surface morphology and external structural features of phytosomes. SEM observations confirm the spherical shape of phytosomal vesicles through visible surface protrusions or bulging and further verify the absence of crystalline materials, contaminants, or impurities, demonstrating the purity and structural integrity of the formulation [60, 61].

X-ray diffraction studies (XRD): XRD is used to evaluate the crystalline nature of phytosomal formulations. A reduction or disappearance of characteristic crystalline peaks of pure phytoconstituents and phospholipids in the phytosome indicates the formation of an amorphous complex. This transformation confirms effective interaction and encapsulation of the drug within the phospholipid matrix. The decrease in crystallinity suggests enhanced solubility and bioavailability of the active compound. Therefore, XRD serves as an important tool for confirming drug entrapment, structural changes, and improved delivery potential of phytosomal systems [62, 63].

Differential scanning calorimetry (DSC): DSC is used to evaluate the crystallinity and thermal behavior of phytosomal formulations. Pure crystalline drugs typically exhibit sharp endothermic peaks at high melting points in DSC thermograms. In phytosomes, these peaks are reduced in intensity or shifted to lower temperatures, indicating decreased crystallinity. This change reflects the formation of complexes between phytoconstituents and phospholipids, leading to enhanced solubility and bioavailability [64]. The reduction in crystallinity improves the balance between hydrophilicity and lipophilicity, thereby enhancing drug performance. Thus, DSC confirms effective complexation and supports the functional advantages of phytosomal systems [65, 66].

Conclusion: The advancement of drug delivery and targeting techniques is increasingly being applied to phytopharmaceuticals, as efficient delivery systems are crucial for the optimal administration of active constituents. Phytosomes represent a novel drug delivery approach designed to enhance the safe, efficient, and targeted delivery of phytoconstituents, particularly those that are hydrophilic and poorly absorbed. These innovative formulations improve the bioavailability of hydrophilic compounds by facilitating their absorption through the gastrointestinal tract and skin. After selecting suitable phytoconstituents, phytosomal systems can be developed for various therapeutic applications. Phytosomes are especially valuable in the management of liver disorders due to their hepatoprotective properties and their ability to improve pharmacokinetic and pharmacodynamic profiles in acute liver diseases of metabolic or infectious origin.

References

1. Rana P, Rani MR, Tripathi V, Kashyap A. Bridging traditional medicine and endocrinology: Assessing herbal and ayurvedic therapies for hypothyroidism. *Mediterranean Journal of Pharmacy and Pharmaceutical Sciences*. 2026; 6(1): 57-61. doi: 10.5281/zenodo.18800493
2. Bhat R, Bhat SS, P N. A systematic review and meta-analysis of traditional Chinese medicine in Parkinsonism. *Mediterranean Journal of Medical Research*. 2025; 2(4): 169-178. doi: 10.5281/zenodo.17344302
3. Rafi IK. Cough care with medicinal herbs: Safe and natural alternatives. *Mediterranean Journal of Medicine and Medical Sciences*. 2025; 1(2): 17-22. doi: 10.5281/zenodo.16763823
4. Patel A, Tanwar YS, Suman R, Patel P. Phytosome: Phytolipid drug delivery system for improving bioavailability of herbal drug. *Journal of Pharmaceutical Sciences and Bioscientific Research*. 2013; 3(2): 51-57. Corpus ID: 51855300.
5. Bombardelli E, Spelta M, Della Loggia R, Sosa S, Tubaro A. Phytosomes: A new approach to enhance the bioavailability of plant extracts. *Fitoterapia*. 1989; 60(1): 1-9. doi: Nil.
6. Waghmode AN, Mali AA, Hagir DN. Phytosome: A novel drug delivery system. *Asian Journal of Pharmacy and Technology*. 2026; 16(1): 39-4. doi: 10.52711/2231-5713.2026.00007
7. Kulkarni GT. Herbal drug delivery systems: An emerging area in herbal drug research. *Journal of Chronotherapeutic Drug Delivery*. 2011; 2(3): 113-119. Corpus ID: 73657714.
8. World Health Organization. Progress report by the Director General. Geneva: WHO; 1991. DN: A44/3.

9. Atmakuri LR, Dathi S. Current trends in herbal medicines. *Journal of Pharmacy Research*. 2010; 3(1): 109-113. doi: Nil.
10. Manach C, Scalbert A, Morand C. Polyphenols: Food sources and bioavailability. *The American Journal of Clinical Nutrition*. 2004; 79(5): 727-747. doi: 10.1093/ajcn/79.5.727
11. Uhumwangho MU, Okor RS. Current trends in liposomes: A review. *Journal of Biomedical Sciences*. 2005; 4: 9-21. doi: Nil.
12. Mukherjee PK, Wahile A. Integrated approaches towards drug development from Ayurveda. *Journal of Ethnopharmacology*. 2006; 103(1): 25-35. doi: 10.1016/j.jep.2005.09.019
13. Jadhav AI, Wadhav AA, Arsul VA, Sawarkar HS. Phytosomes: A novel approach in herbal drug delivery systems. *International Journal of Pharmaceutics and Drug Analysis*. 2014; 2(5): 478-486. doi: Nil.
14. Semalty A, Semalty M, Singh DM, Rawat SM. Phospholipid complexes of naringenin. *Fitoterapia*. 2009; 80(1): 59-62. doi: 10.1016/j.fitote.2008.10.002
15. Keshwani B, Sharma D, Chatterjee A, Jaimini M. Phytosomes: A promising system. *Journal of Chemical and Pharmaceutical Research*. 2016; 8(1): 804-808. doi: Nil.
16. Mukherjee MK, Gantait K, Saha A, Mukherjee BP, Mukherjee PK. Curcumin-phospholipid complex. *Current Drug Delivery*. 2006; 3(1): 31-38. doi: 10.2174/156720106775197839
17. Mukherjee PK, Maiti K, Kumar V. Value-added drug delivery systems with botanicals. *Journal of Pharmaceutical Research*. 2007; 6: 57-60. doi: Nil.
18. Kareparamban J, Nikam P, Jadhav A, Kadam V. Phytosome: A novel revolution. *International Journal of Research in Pharmacy and Chemistry*. 2012; 2(2): 299-310. doi: Nil.
19. Patel PM, Modi CM, Patel HB, Patel UD, Ramchandani DM, Patel HR, Paidia BV. Phytosome: An emerging technique. *Phytopharmacology*. 2023; 12(1): 51-58. doi:10.31254/phyto.2023.12108
20. Afrin S, Jahan I, Hasan AHMN, Deepa KN. Novel approaches to herbal drug delivery. *Journal of Pharmaceutical Research International*. 2018; 21(5): 1-11. doi: 10.9734/JPRI/2018/39143
21. Nizamuddin SFS. Polyphenol-rich black chokeberry (*Aronia melanocarpa*) and its therapeutic potential in type 2 diabetes mellitus: A comprehensive review. *Mediterranean Journal of Medicine and Medical Sciences*. 2025; 1(3): 31-42. doi:10.5281/zenodo.17619107
22. Adeleke PA, Okubena O, Okubena A, Ajayi AM, Okubena O, Jegede FB, et al. Anti-aging potentials of a polyphenol-rich supplement from African *Sorghum bicolor* leaf sheaths: A narrative review. *Mediterranean Journal of Pharmacy and Pharmaceutical Sciences*. 2025; 5(4): 58-77. doi: 10.5281/zenodo.17742769
23. Gandhi A, Dutta A, Pal A, Bakshi P. Recent trends of phytosomes. *Journal of Pharmacognosy and Phytochemistry*. 2012; 1(4): 6-13. doi: Nil.
24. Chauhan NS, Rajan G, Gopalakrishna B. Phytosomes carriers. *Journal of Pharmaceutical Research*. 2009; 2(7): 1267-1270. doi: Nil.
25. Acharya NS, Parihar GV, Acharya SR. Phytosomes: Novel approach. *Pharma Science Monitor*. 2011; 2(1): 144-160. doi: Nil.
26. Patel JJ, Patel RK, Khambholja KM. An overview of phytosomes as an advanced herbal drug delivery system. *Asian Journal of Pharmaceutical Sciences*. 2009; 4(6): 363-371. Corpus ID: 75029405.
27. Wen Z, Liu B, Zheng Z, You X, Pu Y, Li Q. Preparation of liposomes entrapping essential oil from *Atractylodes koidz* by modified RESS technique. *Chemical Engineering Research and Design*. 2010, 88(8): 1102-1107. doi: 10.1016/j.cherd.2010.02.001
28. Chen Z, Wang J, Zhou J, Yu H, Zheng L, Chen Y, Wan X, Zhang W. Tripterygium drug-loaded liposome alleviates renal function by promoting vascularization and inhibiting fibrosis. *Frontiers in Chemistry*. 2024; 12: 1427670. doi: 10.3389/fchem.2024.1427670
29. Barani M, Sangiovanni E, Angarano M, Rajizadeh MA, Mehrabani M, Piazza S, et al. Phytosomes as innovative delivery systems for phytochemicals: A comprehensive review of literature. *International Journal of Nanomedicine*. 2021; 16: 6983-7022. doi: 10.2147/IJN.S318416
30. El-Samaligy MS, Afifi NN, Mahmoud EA. Evaluation of hybrid liposomes-encapsulated silymarin regarding physical stability and in vivo performance. *International Journal of Pharmaceutics*. 2006; 319(1-2): 121-129. doi: 10.1016/j.ijpharm.2006.04.023
31. Sinico C, De Logu A, Lai F, Valenti D, Manconi M, Loy G, Bonsignore L, Fadda AM. Liposomal incorporation of *Artemisia arborescens* L. essential oil and *in vitro* antiviral activity. *European Journal of Pharmaceutics and Biopharmaceutics*. 2005; 59(1): 161-168. doi: 10.1016/j.ejpb.2004.06.005
32. Chen F, Li T, Li S, Hou K, Liu Z, Li L, Cui G, Zu Y, Yang L. Preparation and characterization of *Tripterygium wilfordii* multi-glycoside nanoparticle using supercritical anti-solvent process. *International Journal of Molecular Sciences*. 2014; 15(2): 2695-2711. doi: 10.3390/ijms15022695
33. Priprem A, Watanatorn J, Sutthiparinyanont S, Phachonpai W, Muchimapura S. Anxiety and cognitive effects of quercetin liposomes in rats. *Nanomedicine*. 2008; 4(1): 70-78. doi: 10.1016/j.nano.2007.12.00

34. Wang XR, Gao SQ, Niu XQ, Li LJ, Ying XY, Hu ZJ, Gao JQ. Capsaicin-loaded nanolipoidal carriers for topical application: design, characterization, and in vitro/in vivo evaluation. *International Journal of Nanomedicine*. 2017; 12: 3881-3898. doi: 10.2147/IJN.S131901
35. Gedam S, Bakliwal AA, Talele S, Chudiwal VS. Phytosomes as a Novel Approach for Herbal Phytoconstituents. In: *Enhancing the Therapeutic Efficacy of Herbal Formulations*. 2021; doi: 10.4018/978-1-7998-4453-2.ch010
36. Cott J. NCDEU update. Natural product formulations available in Europe for psychotropic indications. *Psychopharmacology Bulletin*. 1995; 31(4): 745-751. PMID: 8851648.
37. Bombardelli E, Curri SB, Della Loggia R, Del Negro P, Tubaro A, Gariboldi P. Complexes between phospholipids and vegetal derivatives of biological interest. *Fitoterapia*. 1989. Corpus ID: 186835091.
38. Wynn RL. New drug approvals in 2000. *General Dentistry*. 2001; 49(4): 341-345. PMID: 12016673.
39. Moscarella S, Giusti A, Marra F, Marena C, Lampertico M, Relli P, Gentilini P, Buzzelli G. Therapeutic and antilipoperoxidant effects of silybin-phosphatidylcholine complex. *Current Therapeutic Research*. 1993; 53(1): 98-102. doi: 10.1016/S0011-393X(05)80160-2
40. Guha N, Paul A, Islam J, Das MK, Zaman MK. Phytosomes in functional cosmetics. In book: *Nanocosmeceuticals*. 2022; 237-275. doi: 10.1016/B978-0-323-91077-4.00001-6
41. Venkatesan N, Babu BS, Vyas SP. Protected particulate drug carriers for prolonged systemic circulation. *Indian Journal of Pharmaceutical Sciences*. 2000; 62(5): 327-333. doi: Nil.
42. Hudson SA, Anaw JJ, Johnson BJ. The changing roles of pharmacists in society. *International e-Journal of Science, Medicine and Education*. 2007; 1(1): 22-34. doi: Nil.
43. Karimi N, Ghanbarzadeh B, Hamishehkar H, Pezeshki A, Mostafayi H, Gholian M. *International Journal of Current Microbiology and Applied Sciences*. 2015; 4(6): 152-159. doi: Nil.
44. Pandey S, Patel K. Phytosomes: Technical revolution in phytomedicine. *International Journal of PharmTech Research*. 2010; 2(1): 627-631. doi: Nil.
45. Saha S, Sarma A, Saikia P, Chakrabarty T. Phytosome: A brief review. *Scholars Academic Journal of Pharmacy*. 2013; 2(1): 12-20. doi: Nil
46. Mussa FH. Development and evaluation of muco-adhesive buccal films containing metronidazole for the treatment of periodontal diseases. *Mediterranean Journal of Pharmacy and Pharmaceutical Sciences*. 2025; 5(4): 47-57. doi: 10.5281/zenodo.17554356
47. Jain NK. Liposomes as drug carriers. In: *Controlled and novel drug delivery*. 1st ed. CBS Publishers; 2005. ISBN: 81-239-0517-3.
48. El Maghraby GMM, Williams AC, Barry BW. Oestradiol skin delivery from ultradeformable liposomes. *International Journal of Pharmaceutics*. 2000; 196(1): 63-74. doi: 10.1016/S0378-5173(99)00334-6
49. Fry DW, White JC, Goldman ID. Rapid secretion of low molecular weight solutes from liposomes. *Analytical Biochemistry*. 1978. 90(2): 809-815. doi: 10.1016/0003-2697(78)90520-2
50. Dayan N, Touitou E. Carriers for skin delivery of trihexyphenidyl HCl: Ethosomes vs. liposomes. *Biomaterials*. 2000; 21(18): 1879-1885. doi: 10.1016/s0142-9612(00)00063-6
51. Maffei Facino R, Carini M, Aldini G, Bombardelli E, Morazzoni P, Morelli R. Free radicals scavenging action and anti-enzyme activities of procyanidines from *Vitis vinifera*. A mechanism for their capillary protective action. *Arzneimittelforschung*. 1994; 44(5): 592-601. PMID: 8024628.
52. Gupta S, Singh RP, Lokwani P, Yadav S, Gupta SK. The vesicular system is a targeted drug delivery system. *International Journal of PharmTech*. 2011; 3(2): 987-1021. doi: Nil.
53. Hikino H, Kiso Y, Wagner H, Fiebig M. Antihepatotoxic actions of flavonolignans from *Silybum marianum* fruits. *Planta Med*. 1984; 50(3): 248-250. doi: 10.1055/s-2007-969690
54. Kidd PM. Bioavailability and activity of phytosome complexes. *Alternative Medicine Reviews*. 2009; 14(3): 226-246. doi: Nil.
55. Kidd PM. Phosphatidylcholine: A superior protectant against liver disease. *Alternative Medicine Review*. 1996; 1(4): 258-274. doi: Nil.
56. Nazeer AA, Vijaykumar SD, Veeraiyan S. Phytosomes: Emergent promising nano vesicular drug delivery system for targeted tumor therapy. *Advances in Natural Sciences Nanoscience and Nanotechnology* 2018; 9(3): 033001. doi: 10.1088/2043-6254/aade50
57. Bombardelli E, Mustich G. Bilobalide phospholipid complex (Patent: EPO275005). 1991.
58. PK, RK. Phytosome technology: A novel breakthrough for the health challenges. *Cureus*. 2024; 16(8): e68180. doi: 10.7759/cureus.68180
59. Magistretti JM, Bombardelli E. Pharmaceutical compositions containing flavanolignans (Patent: EPO209037). 1987.
60. Das MK, Kalita B. Phytosome: an overview. *Journal of Pharmaceutical and Scientific Innovation*. 2013; 2(3): 7-11. doi: 10.7897/2277-4572.02322
61. Abrol S, Trehan A, Katare OP. Comparative study of silymarin formulations. *Current Drug Delivery*. 2005; 2(1): 45-51. doi: 10.2174/1567201052772918

62. Comoglio A, Tomasi A, Malandrino S, Albano E, Dianzani MU. Scavenging effect of silipide. *Biochemical Pharmacology*. 1995; 50(1): 131-134. doi: 10.1016/0006-2952(95)00127-5
63. Delgi U, Urbino SD. Tolerability and cutaneous sensitization study in healthy volunteers after topical application of glycyrrhetic acid-phytosome® ointment. Unpublished data submitted by CTFA. 2004
64. Sreedharan S, Hegde K. *Pterocarpus marsupium*: An overview of its medicinal properties, phytochemistry, and pharmacology. *Mediterranean Journal of Medicine and Medical Sciences*. 2026; 2(2): 24-30. doi: 10.5281/zenodo.19747490
65. Kaneko Y, Sharmin F, Bulbul N, Atsuzawa K. Backscattered electron imaging of soybean root nodules. *Microscopy*. 2019; 68(2). 181-184. doi: 10.1093/jmicro/dfy146
66. French AD. Idealized powder diffraction patterns for cellulose polymorphs. *Cellulose*. 2014; 21(2): 885-896. doi: 10.1007/s10570-013-0030-4

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