**Emergence of Phytosomes in the Field of Novel Drug Delivery System**

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**Abstract**

In the arena of novel drug delivery system, phytosomes have emerged as a ground-breaking carrier system, owing to elimination of side effects, that are generally caused in case of metallic nanocarriers or those having synthetic origin. Phytoconstituents have been stated to have strong *in vitro* pharmacological activity, although possessing poor *in vivo* absorption. In order to increase their bioavailability and absorption, combatting the drawbacks and undesirable effects of traditional herbal extracts, among various novel drug delivery systems. Phytosomes address the issue of poor bioavailability, apart from delivering medications to targeted sites, it also reduces adverse effects, amends absorption, lowers dose and augments therapeutic efficacy. Many researchers have reported the pharmacological potential of phytosomes and established its supremacy, when compared to that of conventional and liposomal drug delivery systems. Phytosomes are well-known biocompatible nanocarriers that can be employed to increase the solubility and permeability of phytopharmaceuticals. This review aims to provide a comprehensive insight about the characteristics, method of fabrication, application in drug delivery and therapeutics, with the challenges faced and the future prospects of phytosomes.

**Keywords:** Phytoconstituents, nanocarriers, phytosomes, biocompatibility, bioavailability.

**Introduction**

Active components present in medicinal plants like tannins, flavonoids, terpenoids and tannins exhibit poor oral absorption, that restrains their pharmacological as well as therapeutic activity. [1]. The reason of poor absorption of phytoconstituents can be due to polyphenols structure, that are too large to be absorbed and limited hydrophilicity or lipophilicity of the phytoactives, that restricts its passage through gastrointestinal membrane [2]. Herbal drugs that can be packed into vesicles and can exist in nano form can be termed as phytosomes. The phytosome forms an envelope-like coating over the drug, preventing microbes and digestive enzyme from abolishing the actives of herbal extract [3] Phytosome technology is responsible for improved in-vivo performance of herbal extracts due to its target specificity; nano size of phytosomes has resolved the hindrance of poor permeability of large hydrophilic phytoconstituents across biological membrane; improved rate of dissolution and absorption, combined with a better pharmacokinetic profile, provides improved therapeutic effect at lower dose; thus, it can be used in therapeutics [4]. Phytophospholipid complexes, termed as phytosomes, have become a successful method to enhance the bioavailability of active ingredients [5]. In order to improve their bioavailability and absorption and bypass the drawbacks and negative effects of traditional herbal extracts, phytosomes, a unique developing vesicular drug delivery technology, have emerged that includes plant extracts or hydrophilic phytochemicals in phospholipids [6]. The polar head of phospholipids interact with the active components to produce phytosomes [7] Phytosomes may turn into agglomerates on dilution with water, and that bear a resemblance to tiny cells as well as to liposomes. In liposomes, the active component is dispersed in the medium inside the cavity or in the sheets of the membrane, whereas in phytosomes, it is the molecules that is stabilized through hydrogen bonds to the polar head of the phospholipids, which form an essential part of the membrane. Contrary to open vesicles, liposomes are closed ones, consisting of lipid bilayers that can encompass substances in an aqueous partition or numerous lipid bilayers [8-9]. Phosphatidylcholine (or phosphatidylserine) is a bifunctional substance, serving two purposes. Choline (serine) is a hydrophilic compound, while the phosphatidyl moiety is lipophilic. Two-fold solubility of a phospholipid renders it a powerful emulsifier. Consequently, the molecule's choline head bonds to these substances, and the lipophilic phosphatidyl part, which comprises of the body and tail, surrounds the choline-bound material. As a result, the phytoconstituents form the phyto-phospholipid complex, a lipid compatible molecular compound with phospholipids [10-11] The active polar moiety is docked to a phospholipid, acting as an integral part of the membrane, allowing molecules to be stabilised by hydrogen bonding. The micellar assembly of phosphotidylcholine, which is employed in phytosomes, is analogous to that of the cell membrane [12].



**Figure 1: Diagram showing the difference between Lipsome and Phytosome**

**Principle:**

Phytosomes, commonly referred to as phytophospholipid delivery systems, act as a bridge between conventional and modern delivery strategies[13-14].The advent of phytosomes was to improvise the bioavailability of the medicines that are to be originated from the plant sources by incorporating phospholipids. The concept of the phytosomes is the production of lipo-compatible complex molecular compounds by combining phospholipids with standardized plant extracts and water soluble phyto-constituents. This dramatically raises bioavailability and absorption through biological barriers[15]. Phosphatidylcholine, phosphatidylserine, phosphatidylethanolamine, and phosphatidylinositol are the phospholipids that are used, but phosphatidylcholine is the one that is most frequently used because it has been shown to have therapeutic value in the treatment of liver diseases like alcoholic steatosis, drug-induced liver damage, and hepatitis [13][15]. Standardized plant extracts with phospholipids added through the use of phytosome technology have higher bioavailability and better pharmacological and pharmacokinetic properties than regular herbal extracts due to increased absorption. Phospholipids are also employed as natural digestive aids and as carriers of water- and fat-soluble nutrients. Phytosomes can easily cross the lipophilic route of enterohepatic cell membranes and the stratum corneum layer of the epidermis[16]. Phosphatidylcholine, also known as phosphatidylserine, is a chemical with two distinct roles. The phosphatidyl moiety is a lipophilic molecule, whereas choline (serine) is a hydrophilic substance. The phospholipid is a potent emulsifier due to its twofold solubility. The choline head of the phosphatidylcholine molecule binds to these molecules as a result, and the lipid-soluble phosphatidyl portion, which consists of the body and tail, surrounds the choline-bound substance. As a result, the phytoconstituents produce the phyto-phospholipid complex, a molecular molecule with phospholipids that is compatible with lipids. The main factor that imparts better biopharmaceutical properties is the hydrogen bonding or the presence of active hydrogen in the phospholipids moiety.

Phytosomes, a novel and emerging vesicular drug delivery method, include plant extracts or hydrophilic phytochemicals in phospholipids to enhance their bioavailability and absorption and avoid the disadvantages and adverse effects of conventional herbal extracts. They are micelles created by the interaction of phospholipids and water. Polyphenolic plant extracts are used to improve the connection[17]. Through hydrogen bonding and polar contact, the polar functional groups of lipophilic substances bind to the charged phosphate head of phospholipids to create micelles. These micelles hold the polyphenolic chemicals in place. In contrast to liposomes, phytosomes contain the bioactive substance either within the core cavity or in the spaces between the shell membrane layers[18]. The bioactive molecule is a crucial component of this vesicular drug delivery system are phytosome with lipid (one phyto-constituents molecule associated with at least one phospholipid molecule) surrounds and binds phytoconstituents of plant extract. Phytosomes display enhanced absorption because they protect crucial herbal extract components from gut bacteria and digestive secretions[19]. Phosphatidylcholine is a bi-functional molecule due to the hydrophilic nature of the choline moiety and the lipophilic nature of the phosphatidyl moiety[20]. The phytoactive component of the phyto-phospholipid complex binds to the choline head of the phosphatidylcholine molecule, which is then enveloped by the lipid-soluble portion[16]. Consequently, a phytophospholipid complex is produced. Spectroscopic techniques have revealed that molecules are chemically bonded to the choline head of phosphatidylcholine. Bioavailability has been found to increase with the distribution of phytosomes to tissues with improved therapeutic impact.



**Figure 2: Image exhibiting significance of Phytosomes**

**Properties (Chemical, Physical, Biological):**

Phytosomes are specialized formulations in which active plant components attached to the phospholipids, which produces unique chemical, physical, and biological properties that leads to their better effectiveness and applications [21].

**Chemical Properties:**

a. Amphiphilic Nature: Phospholipids, the primary aspects of phytosomes, possess both hydrophilic (water-attracting) and hydrophobic (lipid-attracting) regions. This amphiphilic nature enables phytosomes to self-assemble into bilayer frameworks, replicating the structure of cell membranes.

b. Molecular Structure: Phytosomes consists of a primary centre of active plant components surrounded by a phospholipid layer. The active components can be different phytochemicals such as flavonoids, terpenes, polyphenols and depending on the plant extract used [22].

c. Encapsulation Efficiency: Phytosomes have high encapsulation efficiency means they can effectively encapsulate and maintain a significant number of active compounds, protecting them from degradation and improving stability [23].

**Physical Properties:**

a. Particle Size: Phytosomes usually have a nanoscale particle size, ranging from ten to hundreds of nanometers. That small particle size increases their solubility and absorption properties [24].

b. Colloidal System: Phytosomes form stable colloidal systems in aqueous solutions due to their amphiphilic nature. This colloidal property helps in the dispersion and delivery of active compounds.

c. Transparency: Phytosomes are generally transparent or translucent when dispersed in water, indicating their colloidal nature and uniformity [25].

**Biological Properties:**

a. Improved Bioavailability: Phytosomes significantly enhance the bioavailability of active plant components. The phospholipid coating increases their solubility, allowing for greater absorption through both lipid-based and water-based routes in the body [26]

b. Targeted Delivery: The phospholipid coating on phytosomes promotes their interaction with cell membranes, supporting targeted delivery of the encapsulated compounds to specific tissue or cells [24].

c. Cellular Uptake: Phytosomes strengthen the cellular uptake of active substances due to their phospholipid structure, resulting to higher intracellular concentrations and enhanced therapeutic aspects [24].

d. Biocompatibility: Phospholipids are naturally occurring substances present in cell membranes, causing phytosomes biocompatible and well-tolerated by the body. This property decreases the risk of adverse reactions [22].

e. Synergistic Effects: Phytosomes can be formulated to contain numerous active compounds from different plant extracts. This allows for coordinated delivery and possible beneficial effects of the combined compounds, increasing therapeutic outcomes [24].

**Preparation of Phytosmomes**

Phospholipids can be prepared by various conventional techniques, as well as by novel techniques.

**Solvent evaporation method:**

Phosphatidylcholine is dissolved in 100 mL of non-polar solvent, such as chloroform, under constant stirring by magnetic stirrer. The phytoconstituent is dissolved in 20 mL of a non-polar solvent for example methanol before being added to the phosphatidylcholine-chloroform solution. The clear solution should be agitated for 2 hours before being dried under vacuum at 60 °C, which was subsequently transferred to vacuum at 40 °C and allowed to dry overnight. The light-yellow colored residue is collected, powdered, and sealed, which is a Phyto phospholipid complex [27].

**Anti-solvent precipitation method**

In an organic solvent, the bioactive molecule and the phospholipid are dissolved and a rotating vacuum evaporator is needed to extract the organic solvent at a lower temperature and pressure. In the round bottom flask, a thin layer made of a conjugated mix of phospholipid and bioactive formation would take place. The solvents must be entirely removed from the thin layer with hexane, resulting in a precipitate that is filtered, collected, and stored overnight in vacuum desiccators (24 hrs). Crushed dried precipitate is sieved through #100 meshes in a mortar [28]. The synthesis of the andrographolide phyto-phospholipid complex using dichloromethane as the reaction medium and n-hexane as the final precipitation anti-solvent has been the topic of research that was based on a patented similar approach [29-30].

**Rotary evaporation method**

A specific weight of herbal extract and phospholipids were combined in a glass round-bottom container with 30 ml of water-miscible organic solvent, such as acetone, and stirred for two hours at a temperature below 50°C in a rota evaporator. After continuous swirling with a stirrer, a thin coating can be produced that can be treated with an antisolvent like n-hexane [31-32]. Precipitate obtained is stored for future use.

Traditional methods have numerous drawbacks, including a tedious process, difficulty in extraction, and time consumption. Supercritical fluid methods can be used to change the size, shape, and morphology of material of interest. Apart from having high product purity, crystal polymorphism control, the ability to process thermosensitive substances, a single-step process, and eco-friendly technology, novel fabrication methods have evolved. Gas anti-solvents technique (GAS), Supercritical anti-solvent technique (SAS), cosolvent lyophilization are used [33].

**Gas anti-solvents technique (GAS)**

It is injected into the solution in a closed chamber, from the bottom, to accomplish even mixing. As a result of CO2 gas dissolution, the organic solvent's solubilization power is decreased, resulting in the precipitation of solutes. The particles are then washed with more antisolvent to remove any leftover solvent. Otherwise, during depressurization, those solutes may resolubilize, hampering the stability of product. In comparison to the solvent antisolvent technique, the gas antisolvent technique produces better results when scaled up to industrial levels [34].

**Supercritical anti-solvent technique (SAS)**

By lowering the pressure in the SAS, the solvent is eradicated from the gaseous phase, resulting in submicron-sized particles with a fine size distribution. It is necessary to have CO2 in the supercritical condition, as this and solution are both pumped into a closed chamber from the top. Unlike GAS, this strategy has been proven to work on a broad scale [35].

**Co-solvent lyophilization**

The lyophilization process relies on the sublimation of water from the frozen state. Ice can be sublimated through lyophilization, which is accomplished at temperatures and pressures below triple point. The freezing stage, primary drying, and secondary drying are the three stages that make up the lyophilization process. In a work, an illustration of the application of co-solvent lyophilization was done, to create drug-phospholipid complexes [36].

**Characterization of Phytosomes**

1. **Visualization-** Phytosomes can be envisioned by both transmission electron microscopy (TEM) and scanning electron microscopy (SEM). In a study, a soybean phytosome's TEM image exhibited spherical and rough surfaced vesicles without any particle aggregation. The drug's internal environment and distribution inside the phospholipid mesh can be detected through TEM investigation. The size of these vesicles can be detected using TEM at a magnification of 1000 [37]. The surface morphologies of the samples are characterised using SEM.
2. **Size of particles and zeta potential-** Particle size and zeta potential are two important attributes of these complexes that impacts their stability and reproducibility. Phytosomes have particle sizes ranging from 50 nm to 100 m. Particle size and zeta potential both can be measured using dynamic light scattering (DLS) and photon correlation spectroscopy (PCS) [38]. If the zeta potential values remain in the 20-30 mV range, the particle system is relatively stable, and if it exceeds 30 mV, its stability is high. Curcumin-phytosomes were studied for particle size, polydispersity index (PDI) and zeta potential; it was found to be quite homogenous with a PDI of 0.191 and an average size of 131.8 nm [39].
3. **Entrapment efficiency and drug content-** Entrapment efficiency is detected by ultracentrifugation and the supernatant collected is extracted, with the corresponding solvent, in which the phytoconstituent is soluble, here phase separation takes place. The phase containing drug is checked for detection of drug content, by UV Vis spectrophotometer or HPLC [40-41].
4. **Solubility and partition coefficient**- In order to calculate the apparent partition coefficients, or the solubility in hydrophilic and lipophilic medium, shake-flask method is used [42]. Equal volumes of water, n-octanol containing drug and phospholipid complex are mixed and equilibrated under steady and constant shaking at 37°C for 24 hours in different volumetric flasks.
5. **Drug Release-** This can be ascertained using the dialysis method, where the lyophilized product is reconstituted with water or Phosphate buffer (PBS) and kept in dialysis membrane, tightly sealed. It is submerged in 200ml of PBS, and stirring is continued using a magnetic stirrer. Aliquots of sample are taken periodically and equal volume of buffer is refilled to maintain the sink condition. The withdrawn aliquot is analysed spectrophotometrically for quantification of drug release [43].

**Spectroscopic techniques for analysis**

Spectroscopy, a branch of study that evaluates the spectra of electromagnetic radiation as a function of its wavelength or frequency using spectrographic equipment and other methods to learn more about the composition and characteristics of pharamceuticals. It is the field of study that analyses and evaluates the electromagnetic spectra that emerge from the interaction of electromagnetic radiation with matter as a function of the wavelength or frequency of the radiation[44].In phytosome based drug delivery,various spectroscopic techniques like Fourier Transform Infrared spectroscopy (FTIR), Nuclear Magnetic Resonance (NMR), X-ray Diffraction (XRD) study etc are employed to verify the complex formation by contrasting the outcomes of the individual component with the complexes or to study the reciprocal interaction in between the phospholipids.of phytosome and phytoconstituent incorporated [45-46].

**Fourier Transform Infrared spectroscopy (FTIR) study:**

FTIR spectroscopy may be used to validate the complex's formation by contrasting its spectrum with the spectra of its constituent parts and their mechanical mixes. When phytosomes are micro-dispersed in water or included in very basic cosmetic gels, FTIR spectroscopy is a valuable technique for controlling their stability. Practically, the stability may be verified by contrasting the spectra of the complex in phytosomes with the spectra of its microdispersion in water following lyophilization, over different interval of time. When using simple formulations, it is required to compare the complex's residual spectrum after deducting the spectrum of the excipients (blank) from the spectrum of the cosmetic form at various time intervals[ 47].

Udapurkar and his co-rsesearchers developed diosmin-phospholipid complex (DN-PC) in order to improve its oralabsorption and bioavailability. Different parameters like Solubility studies, Drug content, particle size determination, infrared absorption (FTIR), X-ray diffraction (XRD), Differential scanning calorimetry (DSC) entrapment efficiency,Scanning electron microscopy (SEM) etc. was incorporated to evaluate diosmin -phospholipid complex. The development of the phyto-phospholipid complex was verified by FTIR [48].

In another study,to increase the bioavailability of hydrophobic extracts, Tiwari et al. developed herbal extracts loaded phyto-phospholipid complexes (phytosomes) against Polycystic Ovarian Syndrome.Although the strength of the peaks was significantly lowered, FTIR analyses revealed no changes in the descriptive peaks in raw and extracted herbs. Ex vivo research indicated that phytosomes with low phospholipid contents had good permeability patterns [49].

**Nuclear Magnetic Resonance (NMR) study:**

The H1 NMR and C13 NMR studies have been employed to analyse complex structures related to phytosomes. Investigations related to the chemical shift value, presence and absence of a certain proton's NMR peak can be used to characterize phytosomes. The long tail part of the phospholipid molecule's peak is seen in the 1H-NMR spectra of phytosomes made up of different phytoconstituents, indicating that the tail part does not participate in chemical interactions and acts as a sheath to the choline part present in the centre, linked to the phytoconstituent. Besides, to validate the sort of interaction involved in the complexation, the 13C-NMR is frequently used[50]. Research has been done on the NMR spectra of (+)-catechin and its stoichiometric distearoylphosphatidylcholine complex by Bombardelli & Spelta. The 1H-NMR signal from the atoms involved in the complex's synthesis changes noticeably in nonpolar solvents, with no accumulation of the signal specific to individual molecules. To prevent the proton from being released, the flavonoid protons' signals must be strengthened. All of the signals in phospholipids expand, but the singlet related to the choline N-(CH3)3 undergoes an upward shift. The sample is heated to 60˚, which causes the emergence of certain new wide bands that primarily correlate to the resonance of the flavonoid moiety. In the same study, when recorded in C6D6 at ambient temperature, all the flavonoid carbons are plainly undetectable in the 13C-NMR spectra of (+)-catechin and its stoichiometric complex distearoylphosphatidylcholine. While most of the resonances of the fatty acid chains preserve their original shape, the signals corresponding to the glycerol and choline part of the lipid (between 60 and 80 ppm) broadened and some get shifted. All of the flavonoid moieties' signals reappeared after heating to 60˚, however they were still quite broad and somewhat overlapped [46].

Another research was performed on phytosome-nanosuspensions for silybin-phospholipid complex (SPCs-NPs) to improve bioavailability and hepatoprotection efficacy of silybin. Utilising the optimised SPCs-NPs formulation, physicochemical characteristics such as interactions between silybin and phospholipid and crystalline variation were confirmed by using 1H NMR study. The active protons in silybin and certain phospholipid protons were shown to have broadened widely and became less detectable signals in the 1H-NMR spectra of the SPCs complex, and these protons were engaged in the production of the SPCs complex. The 1H-NMR data further supported the intermolecular interactions between the silybin hydroxyl and the polar head of phospholipids. The complex's NMR spectra also raised the idea that the development of the complex led to concomitant structural alterations in phospholipids [51].

By combining NMR characterization in aqueous solution with DFT theoretical calculations, it was possible to establish the stoichiometry, the host-guest affinity, and the geometry of inclusion in the interaction of aescin with the oligosaccharide hosts β-Cyclodextrin and γ-Cyclodextrin respectively. According to the findings, it was found out that though the inclusion also happens with β--CD, experimental evidence from aqueous-state NMR measurements and theoretical calculations have shown that aescin is more suited for γ--CD, which is the host that is most appropriate for it. The triterpene segment of aescin is incorporated into the host cavity, defining the shape of the γ-CDaescin complex [52].

**X-ray Diffraction (XRD) study:**

When phytoconstituents are complexed, their crystallinity is lost, which increases the hydrophilicity of hydrophobic phytoconstituents and maintains a balance between their hydrophilicity and lipophilicity. The X-RD Analysis can establish the crystallinity as well as the interaction of phospholipid with phytoconstituent. The melting point of the phytosome is much lower than that of pure medicine and exhibits a broad peak. The broad peak is a sign of crystallinity degradation. The diffraction angles (2θ) of phytoconstituents, phytosomes, and phospholipids are also compared. Drug interactions and sheath-entrapment are confirmed by the overall XRD study's finding of drug crystalline peak loss [53].

Besides the above techniques, there are various other techniques available for the characterization of phytosome. For example, for determining the size of the vesicle and verifying the vesicular structure following hydration, the Photon Correlation Spectroscopy (PCS) approach is utilised. By using this approach, the polydispersity of vesicles is studied, providing insight into the distribution of diverse vesicular structural sizes. The PCS study demonstrates that upon hydration, phytosomes mostly form unilamellar liposomal structures [54]. Another simple approach for characterising phytosomes is HPTLC. When the phytosomes are eluted with the appropriate solvent system, they exhibit a retention factor value that is distinct from the phytoconstituents and phospholipids, confirming the formation of a new molecular structure [55].

**Applications of Phytosomes**

The therapeutic benefits of natural plant components for boosting health and curing disorders has attracted more attention in recent years. Still, the poor absorption and low bioavailability of several of these substances have severely limited their usefulness. Researchers and scientists developed "phytosomes," which are specialised formulations that improve the delivery and bioavailability of active plant chemicals, as a creative solution to such problems. Since the prehistoric times, ethnobotanical plants have been utilized to manage a variety of disorders. The plant-based components have strong CNS actions as well as anti-tumor, anti-inflammatory, antinociceptive, anti-obesity, and cardioprotective properties. They also have anti-asthmatic, anti-diabetic, anti-oxidant, and anti-asthmatic properties. To transport the medicine to the site of action without it being metabolised, many drug delivery methods including liposomes, niosomes, transferosomes, ethosomes, phytosomes, colloidosomes, etc. are being developed. The bioavailability and effective dose concentration of phytoconstituents with varied chemical natures are the main issues, which might be resolved by using phytosome technology. Phytosomes are phospholipid vesicles that are joined to one or more phytochemicals via a hydrogen bond [23][56].

1. **Pharmaceutical Applications**:

Phytosomes have transformed the field of medications by improving the therapeutic potential of traditional medicines. By enhancing the absorption and bioavailability of active substances, phytosome-based medications can achieve more reliable and consistent outcomes compared to conventional herbal extracts. For example, phytosomal formulations of curcumin have demonstrated promising outcomes in the treatment of various inflammatory diseases such as arthritis [25].

2. **Nutraceuticals and Dietary Supplements:**

The use of phytosomes in nutraceuticals and dietary supplements is increasing popularity due to their capacity to improve the delivery of bioactive substances, resulting in enhanced health benefits. Dietary supplements including phytosomes of green tea catechins, resveratrol, and grape seed extracts have been recognised for their potent antioxidant properties, which may help in reducing oxidative stress and the risk of chronic diseases [57].

3. **Skin Care Products:**

Phytosomes have found significant application in the cosmeceutical industry, especially in skincare products. Their specific ability to penetrate the skin barrier effectively allows for selective absorption of active herbal components, which may stimulate collagen synthesis, reduce wrinkles, and enhance overall skin health. Products that contained phytosomes of silymarin, derived from milk thistle, are frequently utilised for their anti-aging and protective benefits on the skin [58].

4. **Anti-Inflammatory Agents**:

phytosomes have the efectivity in delivering Anti-inflammatory substances to specific target tissues. By encapsulating compounds like boswellic acids from Boswellia serrata or quercetin from Ginkgo biloba, phytosomes enable targeted administration and enhanced efficacy in treating inflammatory conditions, such as asthma and inflammatory bowel disease [59].

5. **Weight Management:**

Phytosome-based medications have been investigated as well in the context of weight management. The formulations that contained green tea catechins and caffeine as phytosomes have shown potential for stimulating thermogenesis and fat metabolism, which may assist in weight loss and weight maintenance [56][59].

6. **Liver Health:**

The liver serves an essential function in detoxification processes, and phytosomes have been developed to target the liver for therapeutic reasons. Phytosomal compositions of substances like silymarin from milk thistle have been shown to have hepatoprotective effects and might be helpful in managing liver-related disorders [60].

7. **Cardiovascular Health:**

Phytosomes with active compounds obtained in certain plants, such as hawthorn extracts which have demonstrated promising activity in supporting cardiovascular disease. These formulations can help to improve blood flow, decrease blood pressure, and improve overall heart function [22].

8**. Cognitive Function**: Some researchers have explored the use of phytosomes to improve the delivery of medicinal compounds that may support brain health and cognitive function. For example, phytosomal preparations of bacopa extracts have been explored for potential advantages in improvement of memory and neuroprotection [61].

**Conclusion**

Phytosomes indicate a revolutionary advancement in the field of natural medication and therapeutic applications. By enhancing the bioavailability of active plant components, phytosomes provide a more efficient and effective means of utilising the power of nature to promote human health and well-being. The numerous uses of phytosomes, ranging from pharmaceuticals to skin care, indicate their flexibility and potential effect on various aspects of human health. As investigation into this field continues to expand, one can expect to discover further creative uses of phytosomes to cope with complex health challenges and deliver better health benifits for people around the world. However, as with therapeutic approach, further research and clinical trials are needed to fully understand and reduce the benefits of phytosome-based formulations.

The development of phytosomes in the field of novel drug delivery systems serves a major advance that holds an enormous potential for revolutionizing the pharmaceutical and nutraceutical industries. The distinctive composition of phytosomes, achieved through the interaction of active plant compounds to phospholipids, has successfully resolved prevalent challenges connected to the poor bioavailability and limited efficacy of many plant-based compounds. Numerous uses of phytosomes in pharmaceuticals, dietary supplements, skin care, and other fields demonstrate their versatility and potential to address a wide range of health conditions. Their ability to improve the absorption and targeted delivery of bioactive substances has resulted in more effective therapies and improved patient outcomes. Phytosomes have opened up new possibilities for incorporating herbal medications into prevalent healthcare systems with their greater efficacy and stability, phytosome-based drugs have the potential to be as effective as conventional pharmaceuticals in treating different diseases, while offering safer and more economical alternatives.

Furthermore, the incorporation of phytosomes in nutraceuticals and dietary supplements has revealed the therapeutic value of natural substance, empowering people with more potent and trustworthy health-promoting products. In the cosmeceutical industry, phytosomes have cleared the way for innovative skincare compositions that can break down the skin barrier efficiently, providing people with enhanced anti-aging and protective benefits.

Despite the enormous advances made in the field of phytosomes, additional research and clinical trials are necessary to fully explore their abilities and reduce their applications. Long-term safety evaluations and comparative studies using current drug delivery systems will be extremely important to gain greater acceptance and recognition from the medical community.

Scientists, researchers, and healthcare professionals must work together and share their findings as phytosomes continue to gain popularity. This will hasten the creation of new phytosomal formulations and broaden the range of potential uses for them.

The recent development of phytosomes in the field of novel drug delivery systems offers a glimpse into the future of medicine, where the power of nature can be used and optimized to provide more effective, safer, and personalized healthcare solutions for individuals worldwide.

**Future Prospects:**

Numerous phytochemicals have been successfully manufactured as phytosomes, and it is expected that additional phytochemicals can gain from similar formulations. The use of phytosomes in combination with other phytochemicals or the combination of a medicine and a phytochemical in a nano-vesicle are possible future research topics that could result in synergistic effects.Phytochemicals may be used topically for a variety of medicinal and esthetic purposes. Nanoengineered drug delivery methods are utilized to improve the penetration of bioactive polyphenolic phytocompounds across biological barriers, hence enhancing their bioavailability, due to their limited absorption profile. Phytosome nanocarriers are one of these cutting-edge platforms for drug delivery systems for phyto constituents. In comparison to the extract of phytochemicals alone, phytosomes have a greater ability to permeate epidermal layers due to their lipid content and nano-vesicular structure. When it comes to vesicular structure, stability, and skin penetration, phytosomes are comparable to liposomes. However, in phytosomes, the polar head of the phospholipid and the polar functionality of the bioactive components form an H-bond, which allows the phospholipid to interact with the phytochemicals. In comparison to liposomes, this significantly improves the stability and skin penetration of phytochemicals. Originally used in cosmetics, phytosomes are now frequently used in the treatment of cancer, heart disease, inflammation, tumors, and other liver-related illnesses. With this newly created formulation tool, phytosomes has reiterated the significance of herbals in modern drug targeting approaches. By binding specific ligands and antigens to the cellular structures, phyto-phospholipid complexes can also be strong candidates for active targeting in addition to passive targeting. As a result, more illnesses, such as cancer, osteoarthritis, and rheumatism, can be treated with phyto-phospholipid complexes. Such size-controlled products would be helpful in more precisely targeting various microbiological regions such as inflammation and tumors because to their greater penetrability and increased retention. By reducing barriers brought on by inadequate lipid solubility and improving the bioavailability of beneficial phytochemicals like silybin, ginkgo, and poly-phenolic compounds found in olive oil, the development of nanotechnology-based phytosomes may have an impact on the administration of medications. Since combining both natural and synthetic anti-cancer medicines into nanophytosomes considerably increases oral bioavailability and inhibits tumor growth, it is anticipated that nano-phytosomal delivery methods for cancer therapy will advance and extend in the near future. The way hydrophilic plant compounds are employed in cancer treatment may be revolutionized by the utilization of phytosome technology in the nano-formulation of nutraceuticals. Future research may find stimulatory effects when phytosomes are used in conjunction with other phytochemicals or when a drug and a phytochemical are combined in a nano-vesicle. In the very near future, theranostics will also be possible for phytosomes and liposomes encapsulating plant extracts for individualized or personalized therapy. The phytosome formulation process is straightforward, repeatable, and easily upgradable to a commercial scale. The phytosome technology has a bright future as far as applications of hydrophilic plant chemicals and formulation technology are concerned. By successfully delivering the active phytoconstituent in the formulation in a controlled release manner with greater bioavailability and improved bioactivity, the phytosome technology may open a new path in the study of herbal drugs.

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