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Phytosome as Cytotoxic agent delivering system : A Review

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Abstract

Along with the rapid development of herbal medicine formulas, an appropriate drug delivery system is needed to increase its bioavailability. One of them used the phytosome. As a delivery system, it was known to be able to increase the bioavailability of phytomedicine by increasing the permeability of herbal compounds on cell membranes so the absorption of the compound will be increased.

In its development, the phytosome formula was effective for delivering cytotoxic agent compounds, such as quercetin, diosgenin, icariin, tocopherol, and others. Besides, some of these formulas have also been commercialized and patented. The effectiveness and ease of manufacture have made phytosomes a promising drug delivery system in the development of cytotoxic drugs.

Keywords: phytosome, cytotoxic, drug delivery system

Introduction

Phytotherapy has evolved rapidly over the decades. Active compounds from plants are known to have promising effectiveness both *in vitro* and *in vivo*. However, most of these compounds have low bioavailability. For example, quercetin (a flavonoid) which was found to have a cytotoxic effect *in vitro*¹ turned out to have low water solubility, inadequate permeability, and degrades rapidly due to first-pass metabolism². The low bioavailability of quercetin is influenced by low lipid solubility because the sugar

clusters cause it to be hydrophilic, the large quercetin molecule makes it difficult for passive diffusion in the intestine to the bloodstream, and degradation of phenol groups by gastrointestinal bacteria destroys quercetin³. This makes quercetin as one of the flavonoids ineffective as a drug for therapy. This deficiency was answered by the development of drug delivery systems using phytosomes.

Phytosome

Phytosome was first introduced by Indena S.P. A, Italy, which stated that increasing the bioavailability of phytomedicine can be

done by the incorporation of phospholipids with standard extracts. Phytosome is a formula developed to increase the absorption and bioavailability of plant extracts and water-soluble phytoconstituents into phospholipids to produce molecularly compatible lipid complexes. The lipid complex will protect the active ingredients of the drug from degradation during the absorption process without having to reduce the phytochemical components of the fraction. The phytosome is different from the liposome. Where in the liposome, no chemical bonds are formed. Phosphatidylcholine molecules are around the water-soluble substance. There are hundreds or even thousands of phosphatidylcholine molecules around the water-soluble substance. Whereas in the phytosome, phosphatidylcholine and its components in plants will form a molecular complex with a ratio of 1: 1 or 1: 2 depending on the substance that forms the complex, followed by chemical bonds. Because phosphatidylcholine is a component that can dissolve in membrane lipids and water, it can increase the bioavailability of the extract by properly conveying it to the membrane lipids so that it can quickly enter the circulation system⁴.

Advantage of phytosome

It is known that phytosomes are effective in increasing the bioavailability of herbal compounds. The advantages of using phytosome as a drug delivery system are summarized in the following points.

1. **Increase bioavailability.** The bioavailability of herbal extracts increases when formulated with a phospholipid complex and increases absorption in the intestinal tract⁵.
2. **Increase absorption.** The presence of phospholipid complexes can increase the penetration of hydrophilic herbal extracts from the intestinal lumen⁶.
3. **Safe and cost-effective.** Phosphatidylcholine, which is used as a complex in the manufacture of phytosomes, is a part of the cell membrane, so this formula is safe. A synergistic effect can also be obtained from the ability of phosphatidylcholine as a hepatoprotective⁶. This formula can also be developed as a cost-effective commercial cosmetic⁵
4. **Improve diffusion through the skin.** The phytosome formula can also be used to increase permeation through the skin because it's phospholipid on the formula^{5,6}. It can increase the gum of drugs through the skin in the transdermal drug delivery system⁶.
5. **Low dose.** Due to the ease of penetrating the gastrointestinal membrane permeability, the

phytosome formula can have maximum effect at low doses. So that doses requirement is reduced⁵

6. **Low risk.** There are few toxicity data from small scale production⁶. Meanwhile, on large-scale production, no toxicity data were found⁵
7. **Enhance the liver targeting.** Phytosome formula can increase the solubility of phytoconstituent on bile, then it can enhance the liver targeting⁶
8. **Easily developed as a commercial product.** This technology is easy to develop because it is easy to manufacture and there are no complex practical speculations^{5,7}

Preparation Methods

A phytosome can be made in the following ways.

1. **Anti-solvent precipitation.** In this process, phosphatidylcholine and extracts with a molar ratio will be dissolved in an organic solvent, such as 20 mL dichloromethane, acetone. Then, the mixture is refluxed at a certain temperature and time according to the research design. The reflux product is concentrated and treated with an anti-solvent such as n-hexane to obtain a precipitate. The precipitate was then dried using a vacuum desiccator⁹ or made an affiliation¹⁰
2. **Cosolvent.** The extract and phosphatidylcholine are dissolved in an organic solvent, such as methanol. The mixing was carried out by stirring using a magnetic stirrer for 1 hour¹¹
3. **Salting out.** Ethanol is used to dissolve the extract and phosphatidylcholine, then mixing is done by stirring. Precipitation formation is carried out by adding n-hexane to the mixture to form precipitate phytosome¹²
4. **Thin layer hydration.** Fraction and phosphatidylcholine were dissolved in methanol and cholesterol was dissolved in dichloromethane. The mixture is slowly then evaporated with a rotary evaporator at 45°C until the solvent is completely evaporated and a thin dry film is formed on the bottom of the bottle. Then, the thin layer of lipid formed is flowed with nitrogen gas and stored at room temperature for one night before being treated for hydration. The film layer was hydrated with aquabidest on a rotary evaporator at 45°C. The optimization of the method to determine the particle size was also carried out using sonification and homogenizer¹³.
5. **Solvent evaporation.** The extract and phosphatidylcholine were dissolved in ethanol and refluxed for 2 hours using a vacuum rotary evaporator at 30°C, 120 rpm. The residue is then hydrated

with aquadest to obtain phytosome suspension¹⁴

Phytosome As A Cytotoxic Agent Delivering System

In its development, phytosome can be used as a delivery system for cytotoxic agents derived from herbs. **Shalini, et al., 2015** showed that the IC₅₀ value of the extract of *Terminalia arjuna* bark and quercetin positive control experienced a significant decrease after being formulated using phytosome. The IC₅₀ of the extract decreased from 25 ug/ml to 15 ug/ml, while the IC₅₀ quercetin decreased from 2 ug/ml to 0.7 ug/ml. This indicates that the use of phytosomes as drug delivery agents can increase its bioavailability so that inhibition of MCF-7 cancer cell lines can occur at low doses¹⁵.

Liang Xu, et al., 2019 was studied the synthesis of a diosgenin derivative (Di) and screening FU-0021-194-P2 (P2) as one of its derivatives. P2 was then prepared with phytosomes (P2Ps) to increase the water solubility of P2, as well as Di. Its cytotoxic inhibition activity was carried out through human non-small-lung cancer A549 and PC9 cells. The results showed that P2Ps can inhibit lung cancer cells more effectively than Di-phytosome after 72 hours of incubation

through induction of cell cycle arrest and apoptosis¹⁶.

Patil, et al., 2017 made a phytosome for *Carica papaya* extract. *Carica papaya* extract was formulated with a phytosome complex then analyzed for its cytotoxic effect on human leukemia cell line K-562 using the Sulforhodamine B (SRB) assay. The IG50 of the aqueous extract and formula showed values of 75.2 ug/ml and 48.4 ug/ml. These results indicate that the phytosome formula is better as an anticancer than the water extract of *Carica papaya*¹⁷.

Yang Li, et al. 2014 worked on mitomycin C-phytosome. Mitomycin C (MMC) is formulated with complex phosphatidylcholine to form an MMC-loaded phytosome which is then given the addition of a surface-functional form of folate-PEG (FA-PEG). FA-PEG-MMC-loaded phytosome has been shown to increase cellular uptake in HeLa cells and high accumulation in H22 tumor-bearing mice. This indicates an increase in anti cytotoxic activity in vitro and in vivo in the formula compared to injection of MMC¹⁸.

Sundaraganapathy, et al., 2016 was studied root formulation of *Clerodendron paniculatum* Linn extract using phytosome has been carried out and evaluation of its cytotoxic activity was seen using Dalton's lymphoma ascites cell in vivo. The results showed that the

phytosome formulation provided more potent inhibition in cancer cells than the extract¹⁹.

Nazeer, et al., 2017 showed that methanolic extract of *Allium sativa* which contains diallyl disulfide and other phenolic compounds were formulated by phytosome. Its formula showed IC90 and IC50 against the MCF-7 cell line at 108,5 ug/ml and 25,76 ug/ml. The diallyl disulfide was confirmed by HPLC and GC-MS analysis, then the phytosome complex was studied by FTIR and SEM analysis²⁰.

Alhakamy et al., 2020 was studied Icariin (flavonol glycoside). It has been formulated by phytosome to improve its potential as a cytotoxic agent. ICA-Phytosomal showed significantly disturbed mitochondrial membrane potential and cellular of caspase 3. Besides that, the reactive oxygen species and apoptosis were enhanced by its formulation. This study has used OVCAR-3 cells ovarian cancer cells²¹.

Alhakamy et al., 2020 worked on Thymoquinone (TQ, natural polyphenol). It has been formulated by phytosome using phospholipon® 90 H. Optimisation of size confirmed by TEM analysis. Furthermore, cytotoxic activity (IC50 value) showed at $4,31 \pm 2,21 \mu\text{m}$ in A549 human lung cancer cells. Apoptosis and necrosis were increased by activation of caspase 3 and the

reactive oxygen species was increased in A549 cells²².

D. Gallo et al. 2003 was showed an effect of Silipide (Sylibine complex) on human ovarian cancer (HOC) in vivo. Antiangiogenic activity has been shown by downregulating and upregulating the **Vascular Endothelial Growth Factor (VEGF)** and **Angiopoietin-2**. VEGF concentration was a consistent decrease in the tumor specimen after treatment with Silipide. It indicated that Silipide was a great candidate for recurrent ovarian cancer²³.

Narges Mahmoodi et al. 2014 was studied the expression of ESR on breast cancer after treated with Sylibin (natural cytotoxic agents) and its phytosome. The study showed that sylibin-phosphatidylcholine complexes give 2.5-3 times more effective to inhibited cell growth on the T7D cell line and ESR was down regulated²⁴.

Sabzichi et al. 2014 was studied Luteolin phytosome to optimization of Doxorubicin for inhibited MDA-MB 231 cells (Human breast cancer cell line) by downregulated Nrf2 expression. The presence of luteolin-phytosome can suppress the Nrf2 expression, as result cells become sensitive to the drug (Doxorubicin)²⁵.

Hou, Z et al.,2013 was studied MitomycinC-soybean phosphatidylcholine. The design of Mitomycin C-soybean phosphatidylcholine (MMC-SPC) was developed by the combination of the solvent evaporation method and nanoprecipitation. The cytotoxic assay has been shown that MMC-SPC inhibited the H22 cell line. The antitumor effect in vivo indicated that the MMC-SPC had a great curative inhibitory effect on tumor growth and have a lethal effect on hepatocellular carcinoma cells by histopathology study²⁶.

Recent Products

Currently, phytosome products have been developed as anticancer and cytotoxic. Table 1 is a commercial product of phytosome as a cytotoxic and anticancer.

Patents regarding the phytosome curcumin complex-piperine have also been filed in Europe by Di Pierro, Fransesco, 2010. Several formulas of the curcumin and piperine phytosomes are made in the form of film-coated tablets, capsules, sachets, two later controlled-release tablets, orodispersible formulations, and sterile, pyrogen-free injectable solution²⁷.

Table 1. Commercial products of phytosome as cytotoxic and anticancer²⁸⁻³⁰

<u>Source</u>	<u>Phytoconstituents</u>	<u>Products</u>	<u>Indication</u>
<u>Cucurbita pepo</u>	<u>Tocopherol, Steroids, carotenoids</u>	<u>Cucurbita Phytosome™</u>	<u>Anti inflammatory, benign prostatic hyperplasia</u>
<u>Glycine biloba</u>	<u>Genistein dan daidzein</u>	<u>Soyselect Phytosome™</u>	<u>Antiangiogenic, anticancer, cardioprotective, immunostimulatory dan hypocholesterolemic</u>
<u>Olea europea</u>	<u>Verbascoside, tyrosol, hydroxytyrosol</u>	<u>Oleaselect Phytosome™</u>	<u>Antioksidan, antihiperlipidemia, antikanker dan anti-inflamatori</u>
<u>Curcuma longa</u>	<u>Curcumin</u>	<u>Curcumin Phytosome™, Curcuvet®, (Meriva®)</u>	<u>Anti-inflammatory, osteoarthritis, anticancer</u>
<u>Serenoa repens</u>	<u>Phytosterol</u>	<u>Phytosterols</u>	<u>Noncancerous prostate enlargement</u>
<u>Camelia sinensis</u>	<u>Epigallocatechin 3-o-gallate</u>	<u>Greenselect Phytosome</u>	<u>Systemic antioxidant, protection against cancer</u>
<u>Vitis vinifera</u>	<u>Procyanidins</u>	<u>Leucoselect phytosome</u>	<u>Nutraceutical, antioxidant, anti cancer</u>

CONCLUSION

Phytosome is a good delivery system for cytotoxic agents. Many research showed that phytosome can be inhibited by many cell lines more than pure cytotoxic agents. Its ability to increase the absorption of natural compounds and be easily developed made it be promising commercial products. By great design, it would be a safe and acceptable cytotoxic product.

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