



INNOVATIVE PATHWAYS IN MEDICINE : A COMPREHENSIVE OVERVIEW OF NOVEL HERBAL DRUG DELIVERY SYSTEM

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ABSTRACT:-

Herbal medicines, renowned for their therapeutic properties and minimal side effects, are widely used across cultures for managing various health conditions. However, traditional delivery methods often limit their efficacy due to poor bioavailability, rapid degradation, and limited target-specific action. Recent advances in novel herbal drug delivery systems (NDDS)—such as liposomes, phytosomes, niosomes, ethosomes, microspheres, and nanoparticles—present a promising approach to overcoming these challenges. NDDS improves the bioavailability, stability, and targeted delivery of herbal compounds, ensuring controlled release and enhanced therapeutic effectiveness. This review highlights the significance of NDDS in augmenting the efficacy of herbal medicines, focusing on advancements that integrate traditional knowledge with cutting-edge technology to maximize therapeutic potential. Through NDDS, the full pharmacological benefits of phytomedicines can be realized, offering enhanced treatment options for conditions ranging from cardiovascular diseases to cancer. The integration of NDDS with herbal medicine represents a significant step forward in making natural treatments more efficient, accessible, and suited to modern healthcare needs.

KEYWORD:- Herbal medicine, novel drug delivery systems, Liposomes, nanoparticles, bioavailability, traditional medicine , control release, targeted Drug delivery.

INTRODUCTION :-

The herbal remedies has drawn interest from all around the world because of their significant therapeutic benefits,

aesthetic appeal, and increased patient compliance. [1- 2]. Compared to conventional formulations, novel drug delivery systems offer significant advantages for the delivery of herbal medications [3]. The patient receives the recommended dosage of the medication in a manner that ensures it precisely reaches the “site of action” and has therapeutic benefits [4][5]

A lot of focus has been placed on the development of a novel drug delivery system (NDDS) for herbal medications during the last few decades. Traditional dosage forms, such as those with a prolonged release, are not able to meet the needs of the body for both delivering the phytoconstituents to the optimal target site to achieve the maximum therapeutic response and retaining the drug component at a specific rate throughout the course of treatment.

The development of nano-sized dosage forms (polymeric nanoparticles and nanocapsules, liposomes, solid lipid nanoparticles, phytosomes, and nanoemulsion) has several benefits for herbal drugs in phytoformulation research, including improved tissue macrophage distribution, sustained delivery, protection from toxicity, increased pharmacological activity, and enhanced solubility and bioavailability.[6]

Conventional Drug delivery system :-

Traditional Forms of Dosage Many drug delivery and targeting systems are presently being developed in order to reduce drug degradation and loss, avoid negative side effects, boost medication bioavailability, and raise the percentage of the drug stored in the necessary zone. [5]

Novel herbal Drug delivery system :-

Herbal drug delivery systems: novel drug delivery systems (NDDS) Throughout the course of treatment, the innovative drug delivery system utilized with herbal pharmaceuticals should be able to channelize the active ingredient of the herbal drug to its site of action at a rate determined by the body’s demands and the disease’s chronopharmacology.[7]. Various NDDS that have been utilized with herbal drugs and phytochemicals may be broadly categorized into the following groups:

1. Vesicular delivery mechanisms, such as phytosomes, transferosomes, ethosomes, and liposomes
3. Biphasic systems, such as micro/nano emulsions;
2. Particulate delivery systems, such as microspheres, nanoparticles, and micropellets. [8]

Importance of novel herbal drug delivery systems :-

Importance of novel drug delivery systems in herbal medicines Novel drug delivery system is a novel approach to drug delivery that addresses the limitations of the traditional drug delivery systems. Our country has a vast knowledge base of Ayurveda whose potential is only being realized in the recent years. However, the drug delivery system used for administering the herbal medicine to the patient is traditional and out-of-date, resulting in reduced efficacy of the drug. If the novel drug delivery technology is applied in herbal medicine, it may help in increasing the efficacy and reducing the side effects of various herbal compounds and herbs. This is the basic idea behind incorporating novel method of drug delivery in herbal medicines. Thus it is important to integrate novel.

Thus it is important to integrate novel drug delivery system and Indian Ayurvedic medicines to combat more serious diseases..[9]

ADVANTAGES AND DISADVANTAGES :-**Advantages:-**

- They cost less than allopathic medicaments.
- They are good for more than one condition
- They have fewer side effects.
- There are many choices on how to use them.
- They do not require testing.[10]
- The novel herbal drug delivery system can be used to achieve site specificity.
- Improved solubility C bioavailability.
- Controlled drug delivery.
- Protection from physical and chemical degradation.
- Sustained delivery.[11]

Disadvantages :-

- Repercussions could be unforeseen.
- An absence of rules.
- Takes longer to display the outcome.
- Certain medications can have negative side effects if you use them.
- Adverse effects are possible with some plants.[10]
- Stability in the body.
- Drugs that are entrapped leaking.
- The bioacceptability has its bounds
- Outcomes could be unforeseen.
- Certain medications may have negative side effects if you use them.[11]

Herbal drug :-

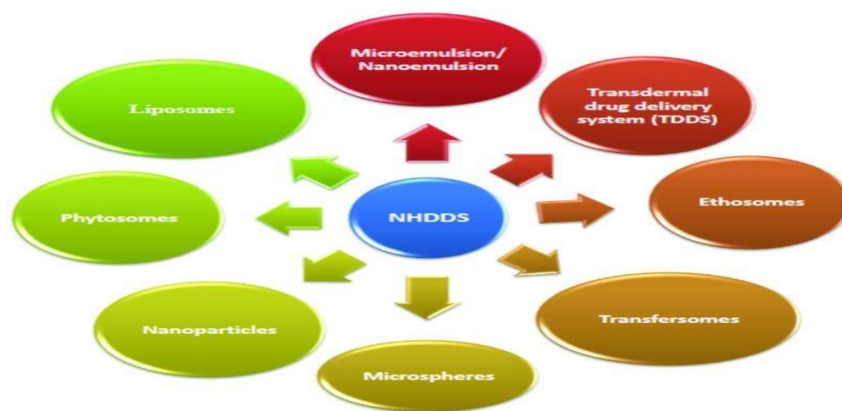
A herbal formulation is a dosage form that contains one or more herbs or processed herbs in predetermined amounts to offer particular nutritional, cosmetic, and/or other benefits intended for use in the diagnosis, treatment, relief, and/or modification of human or animal physiology or structure. [5].

Novel herbal drug delivery system :

A New delivery system is a more sophisticated medication delivery system than a conventional one A novel drug delivery system (NDDS) is characterized by new methods that combine creative formulations, new technologies, and safe drug transport within the body to produce the intended pharmacological effect.[12]

NECESSACITY OF NDDS IN HERBAL :- NDDS Required for Herbal Medicines:-

- To maximize patient compliance and avoid giving the same medication again.[13]
- Innovative herbal medication carriers target particular ailments by administering the medication only to the afflicted portion of the patient's body.[14]
- To reduce drug loss and degradation, avoid negative side effects, and boost drug bioavailability.[15]
- For combination therapy for complicated disorders including diabetes and cardiovascular disease that use "multi drugs and multi targets.[16]

TYPES OF NOVEL HERBAL DRUG DELIVERY SYSTEMS:**Fig. Of Types of NHDDS.****LIPOSOME:-**

Liposomes are consist of one or more concentric lipid bilayer and enclose the aqueous medium in that. Adsorbed lipophiles are inserted into the membrane, and hydrophilic compounds are enclosed in the aqueous compartment. Liposomes are categorized based on surface charge, number of lamellae, and size. Liposomes can be categorized as neutral, cationic, or anionic based on their surface charge [17]. When any drug deliver liposomally it improve efficacy of herbal medication. The liposomes that contain the solvents are spherical vesicles with a diameter of 0.05 to 5.0 μm that are free to float within. The solubility, biodistribution, bioavailability, stability in vitro and in vivo, and modified pharmacokinetics of the substance are all improved by liposomes [18].[19] These are colloidal or micro- particulate carriers, which typically have a diameter of 0.05–5.0 μm and develop naturally when specific lipids are hydrated in aqueous conditions. One, several, or more concebranes may be present in them [20].

The main benefits of using liposomes are as follows:

- highly biocompatible
- easily prepared
- chemically versatile,
- Allowin hydrophilic, amphiphilic, and lipophilic compounds to be loaded; and
- easily modulable pharmacokinetic properties by changing the chemical makeup of the player components

[21]

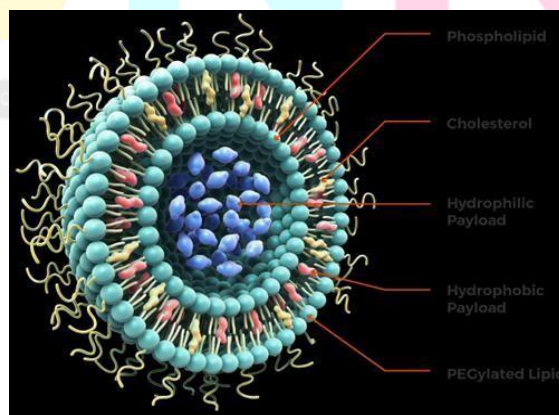
**Fig. No. 1 . Liposomes**

Table 1: Herbal formulations in liposomal drug delivery Systems[22, 23,24]

Plant /constituent	Biological source	Family	Therapeutic category	References
1.Curcumin	Curcuma longa	Zingiberaceae	Anticancer	22,23,24
2.querctin	Found in apple, onion	Amaryllidaceae	Cardiovascular	[22, 23,24]
3. Silymarin (milk thistle)	Silybum Mariannum	Asteraceae	Antioxidant liver disorder	22,23,24,25
4.Green Tea Polyphenol	Camellia sinensis	Theaceae	Anticancer	[22, 23,24]
5.Ginseng liposome	Ginseng (panax Ginseng)	Araliaceae	Adaptogenic.	22,23,24,25
6.Garlic liposome	Garlic (Allium Sativum)	Amaryllidaceae	Antimicrobial, Cardioprotective.	[22, 23,24]
7.Cannabidiol liposomes	Hemp (canabis Sativa)	Cannabaceae	Anti-inflammatory, analgesic.,.	[22, 23,24]
8.Berberin Liposomes	Goldenseal (Hydrstis canadensis)	Ranunculaceae, Berberidaceae	Anti- microbial, Hypoglycemic.,.	[22, 23,24]

PHYTOSOMES:-

“Some” refers to something that resembles a covering for a structure or plants. Phytosomes are tiny entities that resemble cells. Generally, one or two moles of phospholipid and polyphenolic phytoconstituents are reacted to create a phytosome. It could be either 1:1 or 1:2 in ratio. Phytosomes can also be used to increase the pace and extent at which lipophilic herbal ingredients pass through lipid membranes, which is why they are considered a carrier. Additionally, acid-labile herbal medications may also be protected in the gastrointestinal system. [26]. The majority of phytomedicine’s bioactive ingredients are water-soluble substances like glycosides and flavonoids. Phenols Flavonoids are a major class of Bioactive compounds possesses broad therapeutic activities. Most Of the plant flavonoids i.e., glycyrrhizic acid, silymarin also having Cosmetic value apart from their medicinal value, when applied Topically. Plant flavonoids have local action on some diseases like Inflammation, oedema, pain, fungal infections etc . [27]

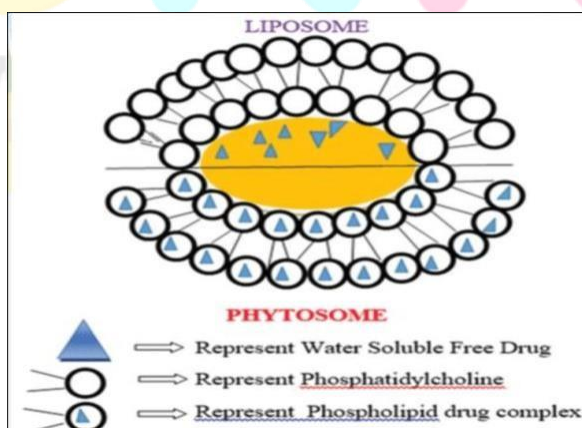


Fig. No. 2.Phytosome

Table 2: Herbal formulations in Phytosome drug delivery Systems[28,29,30,31,32,33,34],

Plant constituent	Biological source	Family	Therapeutic uses	References
1.Ginkgo Biloba phytosomes	Leave of the ginkgo tree	Ginkgoaceae	Used for cognitive support.	[28,29,30,31,32,33,34],
2.Green tea phytosome	Cumellia sinensis	Theaceae	Antioxidant, promoting Cardiovascular	[28,29,30,31,32,33,34],
3.Grape Seed Phytosomes	Vitis vinifera (Grape)	Vitaceae	cancer treatment, protection.	[28,29,30,31,32,33,34],
4.curcumin	Curcuma longa	Zingiberaceae	Anti-inflammatory	[28,29,30,31,32,34],
5. Ashwagandha Phytosome	Withanio somnifera	Solanaceae	managing stress., reducing fatigue.	[28,29,30,31,32,34],
6.Panax Ginseng phytosome	Panax ginseng	Araliaceae	enhance energy, reduce fatigue,.	[28,29,30,31,32,34],

NIOSOMES:-

The niosome, which has a bilayer structure and is created by the self-association of nonionic Surfactant and cholesterol in an aqueous phase. Is one of the most promising drug carriers. It is biocompatible, non-immunogenic, and break down naturally in the body. They enable for controlled and/or continuous medication distribution to the target site and are exceedingly stable and long-lasting.[34] Drug delivery effectiveness can be increased by modifying and improving the characteristics of niosomes, such as their size, number of lamellae, composition, and surface char'e.[35] Niosomes can be used in two different ways for specific drug organization because they have been shown to significantly enhance transdermal medication delivery via the stratum corneum, the main barrier to drug transport through the skin.[35]

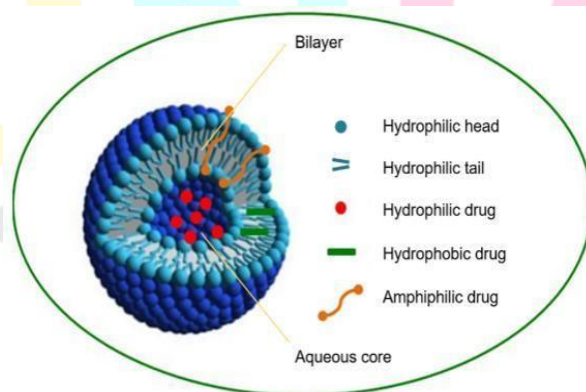


Fig .no. 3 Niosome

Table 3: Herbal formulations in Niosome drug delivery S38systems. [37,38,39,40,41]

Plant /constituent	Biological Source	Family	Therapeutic uses	Reference
1.Curcumin	Curcuma longa	Zingiberaceae	Anti-inflammatory	[37,38,39,40,41]
2.Quercetin Niosomes / Quercefit	Allium Cepa and Capsicum annum	Varies (based on source)	Antioxidant, cardiovascular health.	[37,38,39,40,41]
3.Glycyrrhizic Acid Niosome	Glycyrrhiza Glabra	Fabaceae	Support liver health.	[37,38,39,40,41]
4.Resveratrol Niosome	Polygonum cuspidatum	Polygonaceae	cardiovascular health.	[37,38,39,40,41]
5.Silymarin Niosome	Silybum marianum	Asteraceae	hepatitis.	[37,38,39,40,41]
6.Thymoquinone	Nigella Sative	Ranunculaceae	Antioxidant, immun support..	[37,38,39,40,41]

ETHOSOME:-

Ethosomes are highly concentrated phospholipid, ethanol, and water nanocarrier complexes with a delicate structural makeup. 20%–40% ethanol concentration and 2%–5% phospholipid content are possible in ethersomes. [42] As ethanol can fluidize different intercellular lipids found in the stratum corneum of the skin, ethanolosomes have a better potential for skin penetration than liposomes. It has been observed that while the concentration of phospholipids remains constant, the ethosomes’ size decreases with an increase in ethanol. The increased negative charge on the surface of ethanol-containing phagosomes enhances their colloidal security.[43]

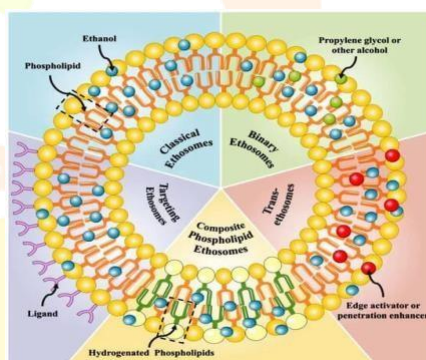


Fig. No. 4.Ethosome

Table 4: Herbal formulations in Ethosome drug delivery Systems[44, 45, 46,47]

Plant / Constituent	Biological souce	Family	Therapeutic uses	Reference s
1.Matrine	genus Sophora flavescens	Leguminoceae	anti cancer, anti rheumatism,	44,45
2.sophoraalopencerid es	Genus Sophora	Fabaceae(Leguminosa e))	Anticance, anti endotoxin	44,46

3.Triptolide	Tripterygium wilfordii plant	Celastraceae	Anti inflammatory	44,47
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TRANSFEROSOMES:-

One of the innovative vesicular systems for transdermal distribution of the active ingredient is the transferosome. They have the unusual ability to accommodate molecules that are hydrophilic, lipophilic, and amphiphilic while delivering medications topically at low and high molecular weights. [48] Even though Transferosomes are 1500 times smaller than water molecules, they can move through minuscule pores almost as well.[49]

Fig. No. 6 Transosome

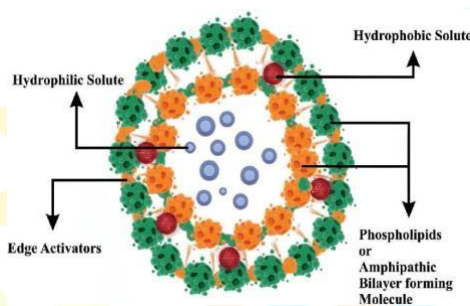


Table 5 : Herbal formulations in Transfosomal drug delivery Systems[50,51,52,53.]

Plant Constituent	Biological source	Family	Therapeutic uses	References
1.Capsaicin transfersomes	capsicum genus of plant	Solanaceae	Analgesic	50,51
2.Colchicine transfersomes	autumn crocus (colchicum autumnnale)	Liliaceae	Antigout	50,52
3.Vincristine transfosomea	It derive from periwinkle plant	Catharanthus roses	Anticancer	50,53

MICROSPHERES :-

These are spherical particles with a size range of 1 to 1000 μm . The medicine is uniformly distributed within the polymer matrix and releases according to first-order kinetics.[54] For the manufacture of microspheres, a variety of synthetic and natural polymers are utilized, such as albumin, gelatine, modified starches, polypropylene, dextran C polylactic acid[54] . One can administer them via injection or by oral means. [55].To increase bioavailability and prolong the release, Zedoary turmeric oil has been microencapsulated into microspheres[56].

Methods of preparation:-

- Spray Drying
- Solvent Evaporation
- Single emulsion technique

- Double emulsion technique
- Phase separation coacervation technique.
- Spray drying and spray congealing
- Solvent extraction
- Quassi emulsion solvent diffusion [57].

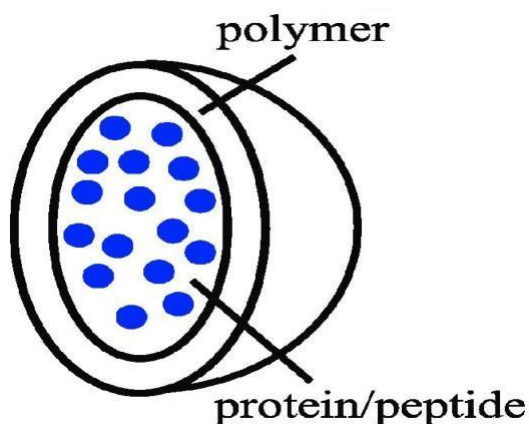


Fig. No. 6. Microsphere

Table 6 : Herbal formulations in Microsphere drug delivery Systems[50, 44,62,63,64,65,66]

Plant/ Constituent	Family	Biological source	Therapeutic uses	References
Chitosan- based plumbagin microspheres	Plumbaginaceae	Plumbago zylanica	Anti-tumor efficacy	50,58
Camptothecin	Nyssaceae	Camptotheca acuminata	Anti cancer	44,59
Gametocides	Araliaceae	Panax genus of plants	Anti cancer	44,60
Piper sarmentosumn	Piperaceae	Piper sarmentosum	Anti diabetic	44,61
Silymarin	Asteraceae	Silybum marianum.	Treatment of Liver diseases	44,62

NANOPARTICLE :- Nanoparticle

Nanoparticles are Hydrophilic and hydrophobic medications can be efficiently delivered through the use of nanoparticles. The submicron size particles with a size range of 10 to 1000 nm are called nanoparticles. Controlling particle size, surface characteristics, and release

of pharmacologically active compounds is the main objective of designing nanoparticles as a delivery system. Biodegradable polymeric nanoparticles have garnered significant interest as possible drug delivery vehicles in recent years [63].

Technique of Preparation includes the following processes:

- Supercritical fluid technology (SCF)

- evaporation of solvents
- nanoprecipitation
- emulsification/solvent diffusion
- salting out
- dialysis
- salting[64]

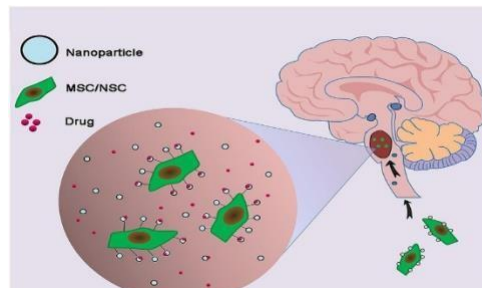


Fig. No. 7. Nanoparticle

Table 7 : Herbal formulations in Nanoparticle drug delivery Systems

Plant constituent	Biological source	Family	Therapeutic uses	References
1.Triptolide Nanoparticle	Tripterygium wilfordii,	Celastarce ace	Hepatocellular carcinoma	65 ,66
2.Artemisinin nanoparticle	Artemisia annua.	Asteraceae	Anticancer	67,68
3.Taxel Nanoparticle	Pacific yew tree, Taxus brevifolia,	Taxaceae	Anticancer	69
4.Barberine Nanoparticle	isoquinoline alkaloid derived from several plants	Berberidaceae	Anticancer	70,71
5.Curcuminoids solid lipid nanoparticle	rhizomes of Curcuma longa	Zingiberaceae	Anticancer and Antioxidant	72,73

PHARMACOSOME :-

Phamacosomes are the term used to describe the zwitterionic, amphiphilic, stoichiometric complexes of polyphenol compounds with phospholipids. It is accurate to refer to these lipid-based drug delivery systems as colloidal pharmaceutical dispersions that improve drug transfer via an organism's membranes, tissues, or cell walls.[74] They work well to accomplish therapeutic objectives like controlled release and medication targeting. [76] Any medication with an active hydrogen atom (-COOH, -OH, -NH₂, etc.) can be esterified to the lipid with or without the spacer chain strongly forming an amphiphilic molecule. The three primary components of a pharmacosome are drugs,

lipids, and solvents. Pharmacosomes have proven to have a variety of applications. NSAIDs (aceclofenac, aspirin, diclofenac, etodolac, ibuprofen, ketoprofen, and naproxen), anti-cancer drugs (camptothecin, cytarabine, gemcetabine, paclitaxel, etc.), and anti-viral drugs (acyclovir, adefovir, didenosine (isoniazid)) are among the many medications given via pharmacosomes.[75]

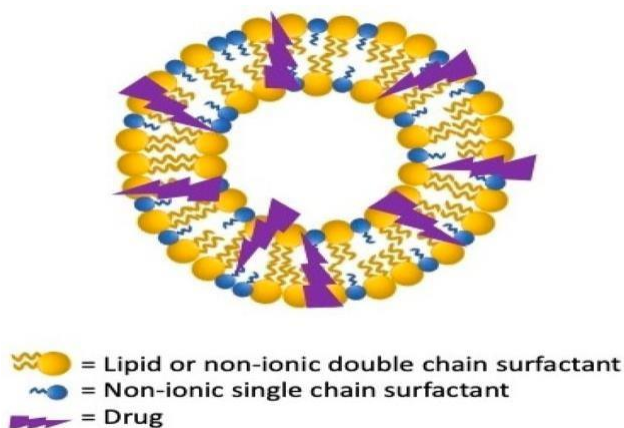


Fig. No. 8.Pharmacosome

Table 8.: Herbal formulations in Pharmacosome drug delivery Systems.

Plant constituent	Biological source	Family	Therapeutic use	Reference
Curcuma	Curcuma longa (Turmeric)	Zingiberaceae	Anti- cancer	77
Quercetin	Allium cepa (Onion),	Theaceae	Antioxidant	78



	Camellia sinensis			
Silymarin	Silybum marianum (Milk Thistle)	Asteraceae	Hepatoprotective	79
4. Ginkgo Biloba Extract	Ginkgo biloba	Ginkgoaceae	Neuroprotective, antioxidant.	80

CURRENT STATUS AND FUTURE PROSPECTS OF NOVEL DRUG DELIVERY SYSTEM:-

The novel drug delivery system's present state and potential for the future in India. Although the investigation of innovative drug delivery systems (NDDS) has been going on for a long time, it has really taken off in the last few centuries. There were two reasons behind the creation of NDDS. The systems' apparent therapeutic advantages come first, and then come the financial ramifications. In order to have more control over a drug's pharmacokinetics and pharmacodynamics after administration, the NDDS have been established and are still being developed. This has led to the development of dosage forms that are safer, more efficient, and more effective than traditional products. When an NDDS reformulates traditional medication, clinical interest in the drug is often rekindled, prolonging its effective market life. About 5% of India's ~Rs. 20000 crore pharmaceutical market is made up of the NDDS market, which is valued at Rs. 1000 crore. The NDDS market in India has enormous potential, based on the gap between the Indian and global markets.[49] India is one of the pharmaceutical industry's major markets. As a result, a lot of global corporations have been eager to grow and invest specifically in this industry. A broad spectrum of excipient usage and development will be highly demanded when new and improved processes in the field of NDDS are developed. India is renowned for its ability to quickly adopt new technology and excipients.

This means that the Indian excipient market will grow in two ways: first, through the export of new organic excipients; and second, through the introduction of new excipients into a variety of cutting-edge delivery systems.(81)

Recently marketed liposomal drug

Onivyde, [82] Epaxal and Inflexal V, [85]

DepoCyt, [83] Amphotec and Ambisome, [86] Visudyne, [84] Liposomal doxorubicin, [87].

CONCLUSION

In this review mention that The integration of novel drug delivery systems (NDDS) with herbal medicines marks a transformative advancement in natural healthcare. By enhancing bioavailability, stability, and site-specific targeting, NDDS addresses the limitations of traditional herbal formulations, making them more effective and reliable. The use of nano- based systems such as liposomes, phytosomes, and nanoparticles improves the therapeutic potential of herbal compounds, offering controlled and sustained drug release, reduced side effects, and improved patient compliance. This approach not only helps in delivering precise doses but also supports the preservation and modern application of traditional knowledge from Ayurveda and other ethnomedicinal practices.

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