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IP International Journal of Comprehensive and Advanced Pharmacology

Journal homepage: https://www.ijcap.in/

Review Article

Novel drug delivery system and characterization in advance techniques

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ARTICLE INFO

Article history:
Received 23-12-2022
Accepted 14-03-2023
Available online 27-03-2023

Keywords:
Gallic acid
Oxidative stress
Nanomedicine
Antioxidant activity
Antiinflammatory activity
Novel drug delivery system

ABSTRACT

Inflammatory diseases, cancer, cardiovascular diseases, Alzheimer's disease, atherosclerosis, and other degenerative diseases are all primarily brought on by oxidative damage disorders, also known as oxidative stress. This article seeks to provide an overview of the therapeutic potential of Gallic acid as a nanocarrier for disorders caused by oxidative damage. Gallic acid has also been found to have anti-inflammatory, antiviral, antibacterial, and significant antioxidant properties. Because of its slow absorption and low bioavailability, the usage of Gallic acid is constrained. The use of nanoformulation can help to remedy this. Nanotechnology has made it possible to deliver medications to the target site quickly and effectively. The medicinal efficacy of naturally occurring potential natural plant compounds has been hampered by poor water solubility and bioavailability.Nanocarriers have been used in recent studies to try to diagnose these issues because they are a logical method. They are created for controlled release at the target place in addition to safeguarding the medication from the internal environment and degradation after administration. Nanotechnology can be employed as a promising new method of medicine delivery to decrease the negative effects of natural substances.

1. Introduction

Chronic disorders include cancer, diabetes, inflammatory diseases, neurodegenerative diseases, and cardiovascular diseases all have oxidative stress as a major contributor to their etiology.[1] The body's cells naturally produce free radicals as a consequence of metabolism. Antioxidants are also produced by cells to combat these free radicals. The inconsistency between the generation and buildup of oxygen reactive species (free radicals) in cells and tissues and the biological system's capacity to purge these reactive products (antioxidants). Diet, lifestyle, and environmental elements like pollution and radiation are among the factors that contribute to oxidative stress and excessive free radical production. The body's immune system can also briefly increase oxidative stress, which leads to minor inflammation.Unchecked oxidative stress can quicken ageing, which may aid in the emergence of a variety of illnesses.[2]

Thus, an unique vesicular delivery method for a herbal medication was developed to combat diseases caused by oxidative damage in order to boost bioavailability and efficacy. Gallic acid, a phenolic molecule with potent antioxidant action, is employed as a result.[3] Gallnuts, tea leaves, oak bark, and other plants all contain significant amounts of this substance.

By including the medication in a carrier system or by altering the drug's molecular structure, new drug delivery technology allows for the control of drug distribution. The use of herbal medicines to treat illnesses with greater therapeutic results and less hazardous side effects is growing in popularity in the modern world. By delivering the treatment to the area of the patient's body that is impacted by

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https://doi.org/10.18231/j.ijcaap.2023.006

the disease, novel herbal drug carriers treat the condition. By delivering herbal medications at a predetermined rate and at their intended sites of action, a novel drug delivery method reduces adverse effects and boosts bioavailability.

2. Advanced Drugs Delivery Systems in Herbal Medicine

The potential of India's extensive understanding of Ayurveda has recently come to light. However, the traditional and antiquated drug delivery technique used to give patients herbal medicines causes a reduction in therapeutic efficacy. The efficiency and side effects of diverse herbal components and herbs are improved when revolutionary drug delivery technology is used in herbal medications.

Incorporation of herbal drugs in delivery system also,

1. Increases solubility
2. Enhances stability, provides protection from toxicity
3. Enhances pharmacological activity
4. Improves tissue macrophage distribution
5. Sustains delivery and
6. Prevents physical and chemical degradation

3. Future Prospects of Nanomedicines

Future nanosized herbal medication delivery techniques may increase efficacy and circumvent problems with plant-based treatments. Nanomedicines' retention in target tissues can be improved, and their clearance from non-target tissues can be sped up, by carefully managing their particle size. These nanomedicines frequently result in increased therapeutic efficacy, reduced dosage, increased bioavailability, and reduced toxicity. These materials typically have particles that range in size from 1 to 100 nm. Effective formulations that have enhanced physical properties lead to improvements in solubility, dissolution rate, oral bioavailability, targeting to specific organs or cells, and/or dosage leading to dose reduction with fewer adverse reactions from the constituent active pharmaceutical ingredients or surfactants.

In addition to the many different types of nanomedicine that have been developed and approved for use in clinical practice, many others are currently undergoing clinical studies.[4] There were 78 nanomedicines on pharmaceutical markets around the world in 2016, and 63 of them had already gotten or were pending drug approval. Polymer nanomedicines with increased half-life and in vivo bioavailability.[5]

3.1. Obectives of novel drug delivery systems

1. To achieve a desired pharmacological response at a selected sites without undesirable interaction at other sites, there by the drug have a specific action with better therapeutic index. Eg.- Cancer chemotherapy .
2. For drugs to reach targeted site with less or no side effects.
3. To minimize drug degradation.
4. To increase the bioavailability of drug.

3.2. Advantages of novel drug delivery systems

Novel drug delivery systems in herbal medicines have the following advantages:

1. They enhance drug stability.
2. They improve drug bioavailability.
3. They provide protection against toxicity.
4. They enhance the pharmacological activity of drugs.
5. They provide sustained drug delivery.
6. They provide protection from physical and chemical degradation.

3.3. Types of novel herbal drug delivery systems

A unique drug delivery system can use a variety of formulations, such as phytosomes, liposomes, niosomes, transferosomes, ethosomes, dendrimers, etc.[6]

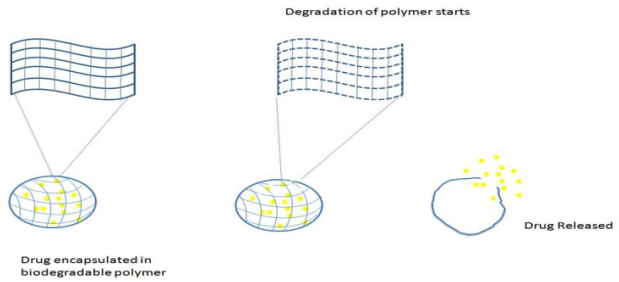

Fig. 1: Encapsulation technique

3.4. Phytosomes

A revolutionary technology called phytosome first appeared in 1989. Phyto denotes a plant or herb, and some refers to a structure that resembles a cell. A regulated and sustained release delivery device known as a phytosome uses nanosized (100 nm) phytoconstituents or herbal extracts in a phospholipid complex system. When a standardised extract or phytoconstituent is combined with a stoichiometric quantity [1:1 or 1:3] of phosphatidylcholine in a non-polar solvent, phytosomes are created.[7] It is made to improve their bioavailability and penetration. Drugs with a weak tendency to self-aggregate and poor water solubility are best suited for phytosomes.

3.5. Liposomes

Liposomes are spherical colloidal structures created when lipid bilayers self-assemble. Normally, cholesterol and

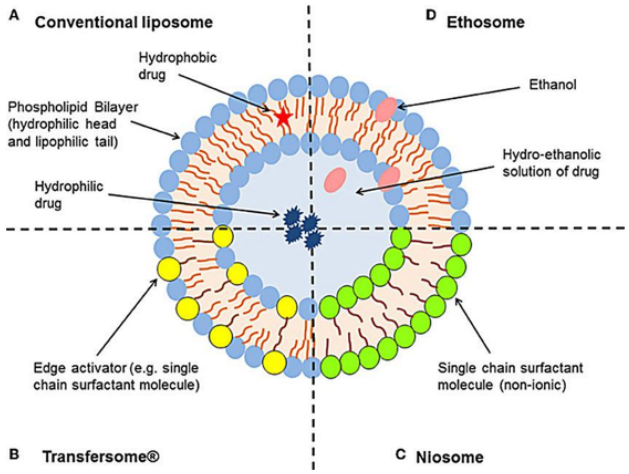

Fig. 2: Liposomes

organic, non-toxic phospholipids make up membranes.[8] They are between 25 and 2.5 nm in size. They can contain medications with various levels of solubility or lipophilicity. They contain a portion of the solvent, which freely diffuses inside of them. They have the ability to encapsulate both lipophilic and hydrophilic molecules.

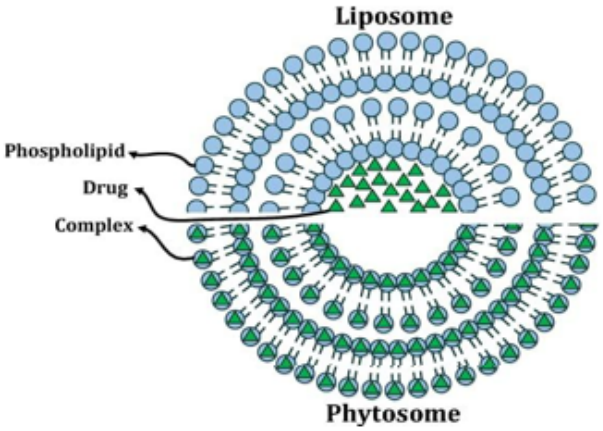

Fig. 3: Structure of liposome and phytosome

3.6. *Niosomes*

Niosomes are microscopic lamellar structures created by mixing cholesterol, a charge-inducing substance, and a non-ionic surfactant, then hydrating the mixture in water. They include both hydrophobic and hydrophilic moieties, which enables them to hold medicinal molecules with a variety of solubilities.

Due to their capacity to lower systemic toxicity by encapsulating treatment drugs and minimise elimination of such agents from the body via gradual drug release, niosomes have numerous pharmacological and therapeutic applications.[9] Due to their special structure, they can entrap a variety of hydrophilic and amphiphilicmedicines.

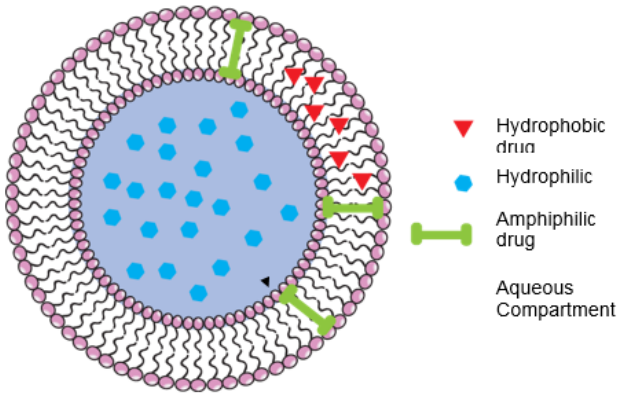

Fig. 4: Structure of niosome

3.7. *Transferosomes*

The word "transferosome" is a combination of the Greek word "soma," which means body, and the Latin word "transferre," which means to carry across. They are synthetic vesicles that resemble real cell vesicles. They contain phospholipids as its major component, along with 10–25% surfactant (such sodium cholate), and 3–10% ethanol[10]. In order to aid transferosomes squeeze through the stratum corneum pores, the surfactants act as edge activators and provide them ultra-deformability.

Without experiencing any appreciable loss, they can bend and squeeze through the small opening (between 5 and 10 times smaller than their own diameter). Their high deformability makes it easier for intact vesicles to penetrate. For both low and large molecular weight medications, they can serve as a carrier.

3.8. *Ethosomes*

The well-known drug carrier liposome is slightly changed to create ethosomes. They are phospholipid-, alcohol-, and water-containing soft lipid vesicles.[11] The alcohols are ethanol and isopropyl alcohol in relatively high concentrations. They can range in size from a few nanometers (nm) to a few microns (μ). Ethosomes have a higher transdermal flux and quickly penetrate the skin's layers.

They increase the medicine's ability to penetrate the skin during transdermal drug delivery. They have a wide range of applications in the medical, veterinary, and cosmetic industries.

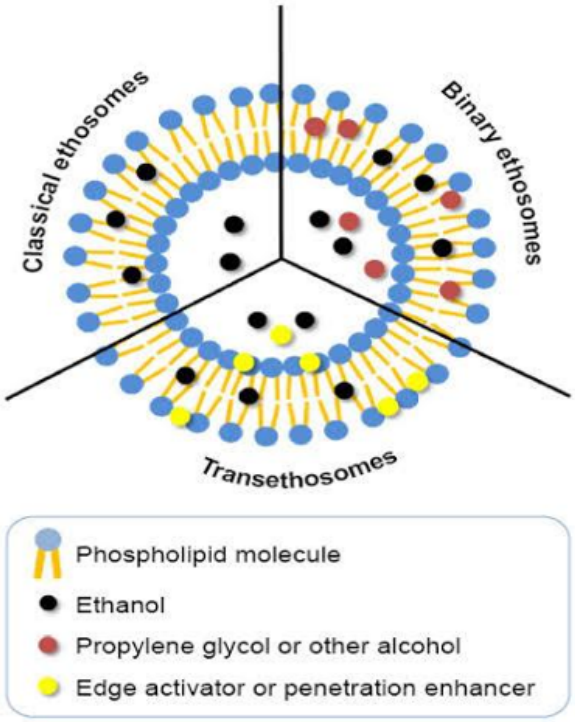

Fig. 5: Structure of ethosomes system

3.9. Incorporation of herbal phytoconstituent – gallic acid, in novel vesicular delivery system

NDDS has delivered a variety of beneficial phytoconstituents with success. The creation of innovative medicine delivery methods for plant actives and extracts therefore has a lot of potential.[12] Drugs made from plants have a huge potential for healing. Standardized plant extracts have a much better absorption profile when given through a novel drug delivery system. This allows them to pass through the biological membrane, increasing their bioavailability.[13]

Several fruits and medicinal plants contain phenolic compounds, a class of phytochemicals that includes gallic acid. A synonym for gallicacid is 3,4,5-trihydroxybenzoic acid.[14] Numerous advantageous properties of gallic acid, such as its anti-inflammatory, antioxidant, and anti-cancer properties, have been connected to it.This substance's therapeutic effects have been noted in the,

1. Gastrointestinal - e.g.: IBD
2. Neuropsychological - e.g.: neurotoxicity
3. Metabolic – e.g.: dyslipidemia
4. Cardiovascular disorders – e.g.: cardiac fibrosis
5. Respiratory disease – e.g.: pulmonary fibrosis
6. Urogenital disease – e.g.: renal fibrosis
7. Dermal disease – e.g.: melanoma
8. Inflammatory disease – e.g.: arthritis
9. Malignancies – e.g.: colorectal cancer
10. Oral issues – e.g.: bacteria induced enamel caries.

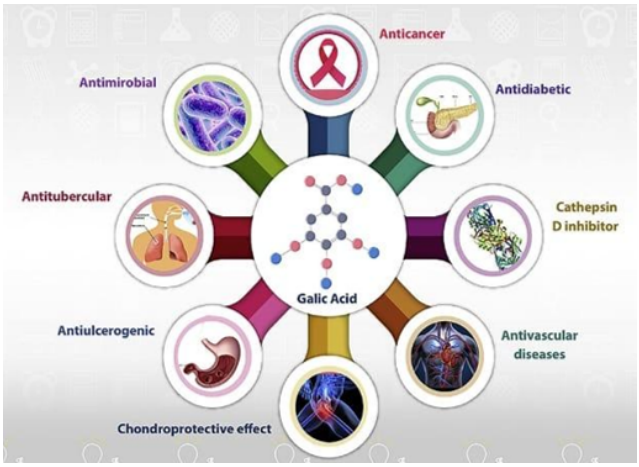

Fig. 6: Mechanism of action

3.10. Antioxidant activity

Antioxidants can reduce oxidative damage indirectly by increasing or decreasing the activity of antioxidant enzymes, or they can reduce oxidative damage directly by interacting with free radicals.[15]

Antioxidants can reduce the amount of free radicals in cells by either increasing the activity of antioxidant enzymes including superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPX), or by reducing the generation of reactive oxygen species (ROS) and lipid peroxidation.

3.11. Anti-inflammatory activity

Anti-inflammatory reduces inflammation, by inhibiting the enzymes cyclooxygenase (COX-2), prostaglandins (PGE-2), nitric oxide signal pathway (NO), tumor necrosis factor (TNFα).

3.12. Anti-cancer activity

The efficiency of chemotherapy can be increased by using GA and its derivatives alone or in conjunction with other anticancer drugs.[16] One way that GA causes apoptosis is by producing reactive oxygen species (ROS), controlling apoptotic and anti-apoptotic proteins, and suppressing apoptosis. Depending on the type of cancer being researched, GA may also promote oncogenes, inhibit matrix metalloproteinases (MMPs), and arrest the cell cycle.

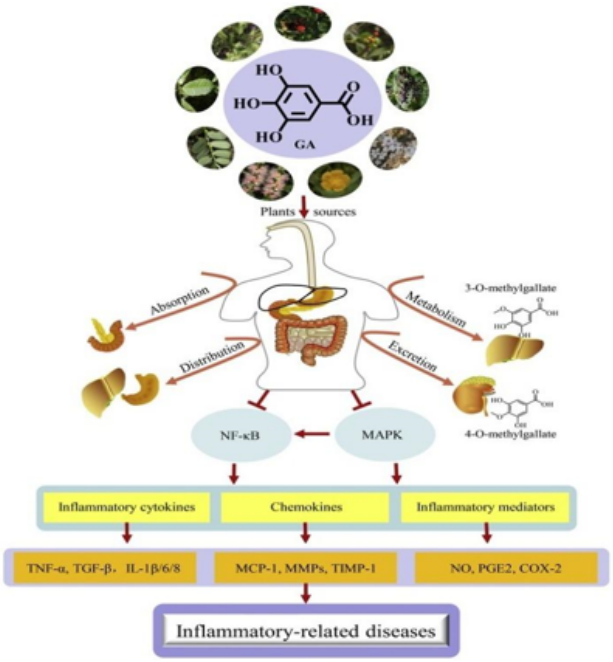

Fig. 7: Role of gallic acid against inflammatory relateddiseases

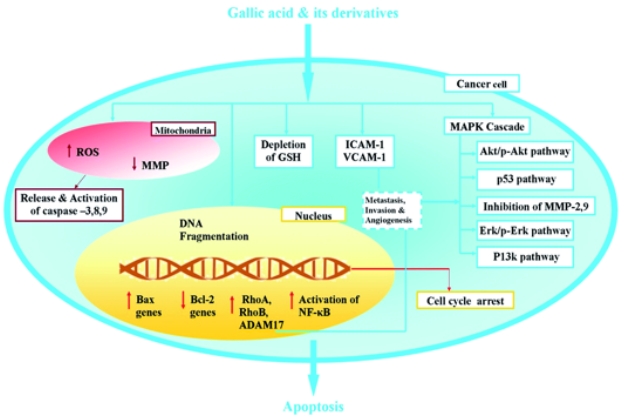

Fig. 8: Mechanism of gallic acid against cell cyclearrest

3.13. Utilization of gallic acid as nanocarriers

The melting temperatures of the pure gallicacids are 235–240 °C, and they are needle-like white or light brown crystals or powders (decomposition). When heated to between 100 and 120 °C, it loses crystallised water, and when heated to more than 200 °C, it releases carbon dioxide. GA is a tri-phenolic molecule with a low molecular weight that has good anti-inflammatory and anti-oxidative properties. It can be dissolved as follows:

Water that is boiling is followed by acetone, ethanol, glycerol, water that is 25 °C, ether, benzene, chloroform, and petroleum ether.

Gallic acid has all of the aforementioned health advantages, but its use is limited by its

1. Poor absorption,
2. Quick excretion, and
3. Low bioavailability.
4. The pharmacokinetic characteristics of gallic acid are also influenced by pathological conditions.

These problems could be solved by nanoformulation. The discipline of nanomedicine has expanded significantly over the past ten years in an effort to improve the targeted uptake of active therapeutic chemicals and address problems with drug delivery to the target tissue. Additionally, nanostructures allow the release of combined medications at the prescribed dose because they stay in the blood circulation system for a long time.

4. Conclusion

Because of their potential for enzymatic breakdown, poor bioavailability, and inadequate penetration of the intestinal mucosa, many drugs may not be given via conventional methods. The creation of a novel drug delivery system (NDDS) aims to address the aforementioned drawbacks. The highly acidic pH of the stomach has a significant likelihood of destroying numerous components, even in the case of herbal extracts. The liver may process other compounds before they enter the bloodstream. As a result, the necessary dosage of the medication might not get into the blood. There won't be a therapeutic impact if the medicine doesn't get to the blood at the'minimum effective level,' as it is also known.As a result, NDDS is a highly efficient, long-lasting, and speedily performed drug delivery device. Indian Ayurvedic medicines and innovative drug delivery systems must work together to battle progressively severe ailments because many natural treatments have been demonstrated to be more effective than medications or surgery without the negative side effects. By using this technique, the patient receives the ideal dosage of the drug in question, ensuring that it immediately begins to function at the precise "site of action." A versatile antioxidant with potential therapeutic and commercial uses, gallic acid is a natural phenolic chemical.Gallic acid derivatives have also been discovered in a variety of phytomedicines, which have a variety of biological and pharmacological effects, such as scavenging free radicals, interfering with cell signalling pathways, and causing cancer cells to apoptose. As a result, the gallic acid-amalgamated nanostructure stays in the blood circulation system for a long time and releases the medication at the appropriate amount.

A summary of the significance of NDDS, the preventive effects of gallic acid, and the underlying pharmacological processes in the pathophysiological process of these oxidative damage illnesses are attempted in the current review. The information provided here suggests that

gallic acid's powerful anticancer and apoptosis-inducing capabilities are caused by both its pro-oxidant and antioxidant actions, although its antioxidant action is primarily responsible for the other pharmacological effects. Gallic acid therefore has the potential to be developed into a flexible adjuvant or perhaps a pharmaceutical medication with exciting possibilities for both medical and industrial uses.

5. Conflicts of Interest

None.

6. Source of Funding

None.

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Cite this article: Sandhiya.V, Deepika A, Jain PS, Swetha B, Evangilin PT. Novel drug delivery system and characterization in advance techniques. *IP Int J Comprehensive Adv Pharmacol* 2023;8(1):36-41.