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Review On The: Nanoformulation Of Herbal Extracts.

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❖ **Abstract:-**

Herbal medicines have been used for centuries due to their therapeutic potential and relatively low Toxicity. However, many herbal extracts suffer from limitations such as poor solubility, instability, Low bioavailability, and rapid metabolism, which restrict their clinical applications. Nanoformulation approaches—such as nanoparticles, liposomes, phytosomes, nanoemulsions, Dendrimers, and nanogels—have emerged as promising strategies to overcome these limitations. This review highlights different nanoformulation techniques applied to herbal extracts, their Advantages, challenges, and future perspectives in phytomedicineUtilizing plant extracts to Produce silver nanoparticles (SNPs) is a sustainable and practical substitute for traditional Chemical and physical methods. This review focuses on the various uses of plant-mediated SNPs In photocatalysis, environmental cleanup, and biomedicine.

❖ **Keywords:-**

Herbal extracts; Nanoformulation; Nanoparticles; Phytosomes; Liposomes; Nanoemulsions; Solid,Lipid nanoparticles; Green nanotechnology; Bioavailability; Phytomedicine,treatment .

❖ **Introduction:-**

To offer healthcare and guarantee human well-being, there is a growing need for natural Substances, particularly in the food, pharmaceutical, and cosmetic industries. An estimated 200,000 natural chemicals originating from higher plants, animals, fungi, and marine organisms Are currently recognized and have been studied in both contemporary drug discovery and Complementary and alternative medicine .An essential part of traditional medicine, medicinal plants have a long history of use and significant Therapeutic potential. 80% of people in underdeveloped nations rely on natural medicines to meet Their everyday medical needs, according to the World Health Organization .Designing, creating, measuring, and applying materials and devices whose lowest functional Organization appears on the nanoscale in any one of their dimensions (a trillionth of a yard) is the Focus of the scientific and engineering discipline known as nanotechnology . **(1,2,3,4)**

❖ **Many nanotechnology-based systems have been created in recent decades, such as:**

1.Nanoparticles made of polymers

2.Lipid nanoparticles in solid form

3.magnetic nanoparticles

4.Nanoparticles of metal and inorganic

5.The use of quantum dots

6.Micelles of polymers

7.Micelles made by phospholipids

8.Nano-liposomes in colloidal form

9.Dendrimers .

10. Zeolitic imidazolate framework.**(5)**

❖ **Types of Nanocarriers Used for Herbal Extracts**

1.Polymeric nanoparticles PLGA, chitosan, alginate, PEGylated polymers Mechanisms and Applications

2.Lipid-based nanoparticles Solid lipid nanoparticles (SLNs)Nanostructured lipid carriers (NLCs)Lipid–polymer hybrid systems

3.Liposomes and nanoliposomes Composition, advantages, drug encapsulation efficiency

4.Nanoemulsions and microemulsions Use in essential oils and hydrophobic herbal extracts

5.NanomicellesSurfactant-based delivery for poorly soluble phytochemicals

❖ **Nanoformulation Techniques**

Solvent evaporation

Nanoprecipitation

High-pressure homogenization

Ultrasonication

Supercritical fluid technology

Coacervation

Self-assembly technique

❖ **Nanoherbal Medication Delivery Method**

In the past two decades, significant efforts have been directed toward developing novel drug Delivery systems (NDDS) for herbal medicines. Although plant-based remedies have been used For centuries to treat various diseases, their clinical effectiveness is often limited by poor stability And low lipid solubility. To overcome these challenges, researchers are formulating advanced Herbal preparations that incorporate natural plant constituents into innovative delivery platforms. These nanoherbal delivery systems can enhance thetherapeutic potential of phytomedicines by Improving their bioavailability and stability.

Moreover, such systems are relatively easy to Fabricate and enable the controlled release of active compounds within the body .Numerous uses Of NCs in nanomedicine, as well as the difficulties and emerging prospects in the sector, have been Studied in several ways **(6)**

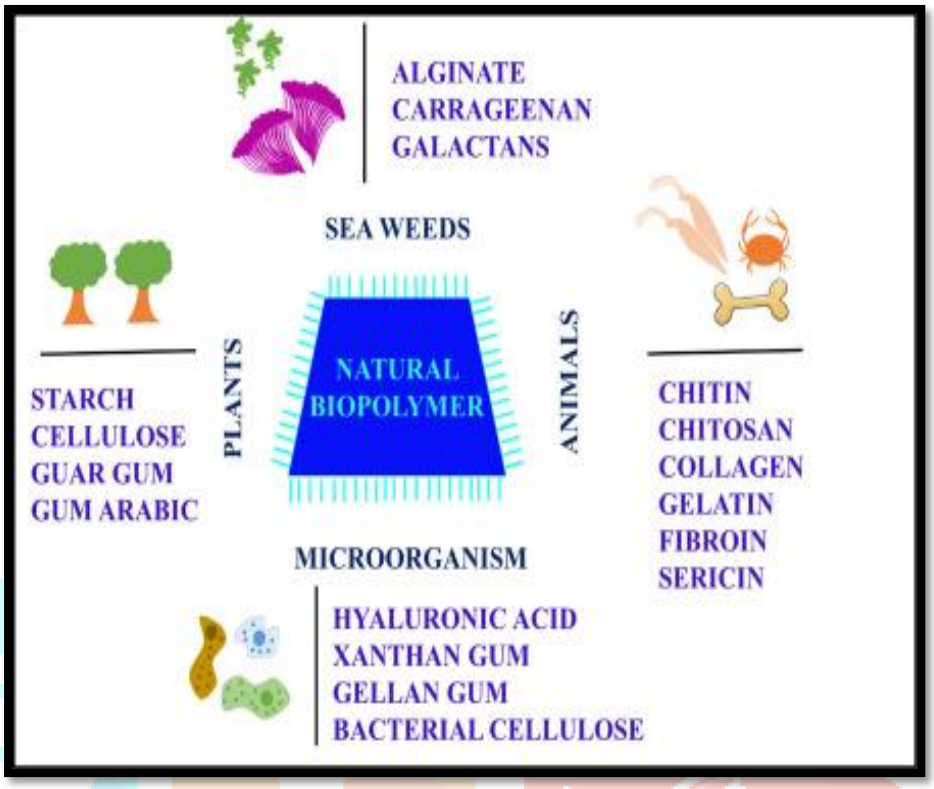

Fig.1 The natural biopolymers that are utilized in the nanoherbal medication delivery system asWell as the sources of these materials.

❖ Evolution of Nanotechnology in Modern Medicine (Expanded Version)

The evolution of nanotechnology in modern medicine reflects a continuous shift from conventional Drug delivery systems to highly engineered nanoscale therapeutic platforms. Early foundational Research by Emerich and Thanos established the conceptual basis of using nanoparticles to Overcome limitations of traditional pharmacotherapy, such as poor solubility, rapid drug Degradation, and non-specific distribution. Their work demonstrated that nanoscale carriers could Protect drugs from enzymatic breakdown, prolong systemic circulation, and deliver therapeutic Molecules directly to diseased tissues, laying the groundwork for the first generation of Nanomedicines **(3).**

❖ Physicochemical Properties of Nanoherbal Formulations

1.Particle Size and Size Distribution

2.Surface Charge (Zeta Potential)

3.Morphology and Structural Characteristics

4.Solubility Enhancement and Aqueous Dispersibility

5.Release Kinetics and Controlled Delivery

6.Stability and Shelf-Life

- **Application of nano herbal plants:**

Nanoparticles (NPs) are versatile materials with applications across numerous scientific domains, Particularly in nanomedicine. They are utilized in precise diagnostic systems, tissue regeneration Following thermal or radiation-induced damage, targeted drug delivery, and gene therapy **(7).**

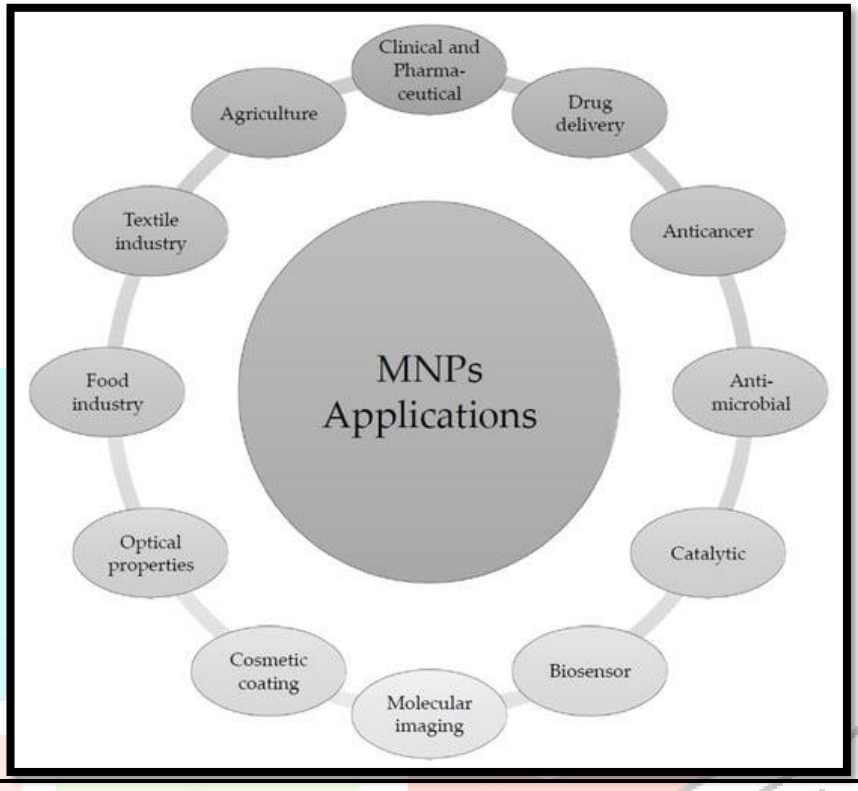

Fig no.2 MNPs Applications

- **Synthesis of Nanoparticles:**

1.Polymer Nanomaterials

2. Magnetic Nanomaterials

- **Nanocarrier system classification**

The development of NDDS for the encapsulation of natural plant extracts into organic, inorganic, And hybrid nanoparticles has advanced significantly in recent years Improvements in solubility, pharmacological activity, tissue distribution, bioavailability, safety, Stability, protection from physical and chemical damage, decreased toxicity, and targeted or Prolonged administration are just a few of the many benefits that these NDDS have been Demonstrated to offer over conventional technique.

- **Interaction of Nanoparticles With Biological Systems**

The interaction of nanoparticles (NPs) with biological systems is governed by their surface Chemistry, size, charge, morphology, and stability, which collectively determine their cellular Uptake, biodistribution, pharmacokinetics, and therapeutic performance. When nanoherbal Formulations enter the body, they immediately encounter a complex biochemical environment Containing proteins, enzymes, lipids, and extracellular matrices, which can significantly modify Their behavior and therapeutic activity **(8).**

❖ **Key nano Drug Delivery Systems:**

1 .Phytosomes

Plant-based medicines and nutraceuticals are encapsulated in lipid-based nanocarriers called Phytosomes, which also include phospholipids.

2.Liposomes

Liposomes, which are made of phospholipid bilayers, are one of the oldest and most popular drug Delivery systems. These structures improve the efficacy of medications, phytopharmaceuticals, Nutraceuticals, and other bioactive agents by encapsulating a range of molecules, including as Lipid-soluble, water-soluble, and amphiphilic chemicals Liposomes have the ability to encapsulate Macromolecules like vaccines as well as tiny compounds like antimicrobials and anticancer Medicines.

3. Transfersomes

Advanced lipid-based drug delivery devices called transfersomes are intended to improve the Transdermal administration of medicinal substances

4. Nanocrystal

Crystals in nanoparticle form Drug particles that are pure and solid and stabilized by stabilizers Or surfactants are called nanocrystals.

5. Ethosomes

Ethosomes are elastic lipid-based carriers made of water,phospholipids, ethanol, and isopropyl Alcohol. In order to promote deeper tissue penetration and systemic circulation, these nanocarriers Improve the topical administration, transdermal transfer, and trapping efficiency of hydrophilic, Lipophilic,anamphiphilic medications The rhizome extract of Zingiber zerumbet was incorporated Into ethosomes for antifungal purposes. When compared to the liquid extract formulation, this Ethosomal formulation notably improved the skin penetration and retention of the extract's active Ingredient, zerumbone **(9,10,11)**

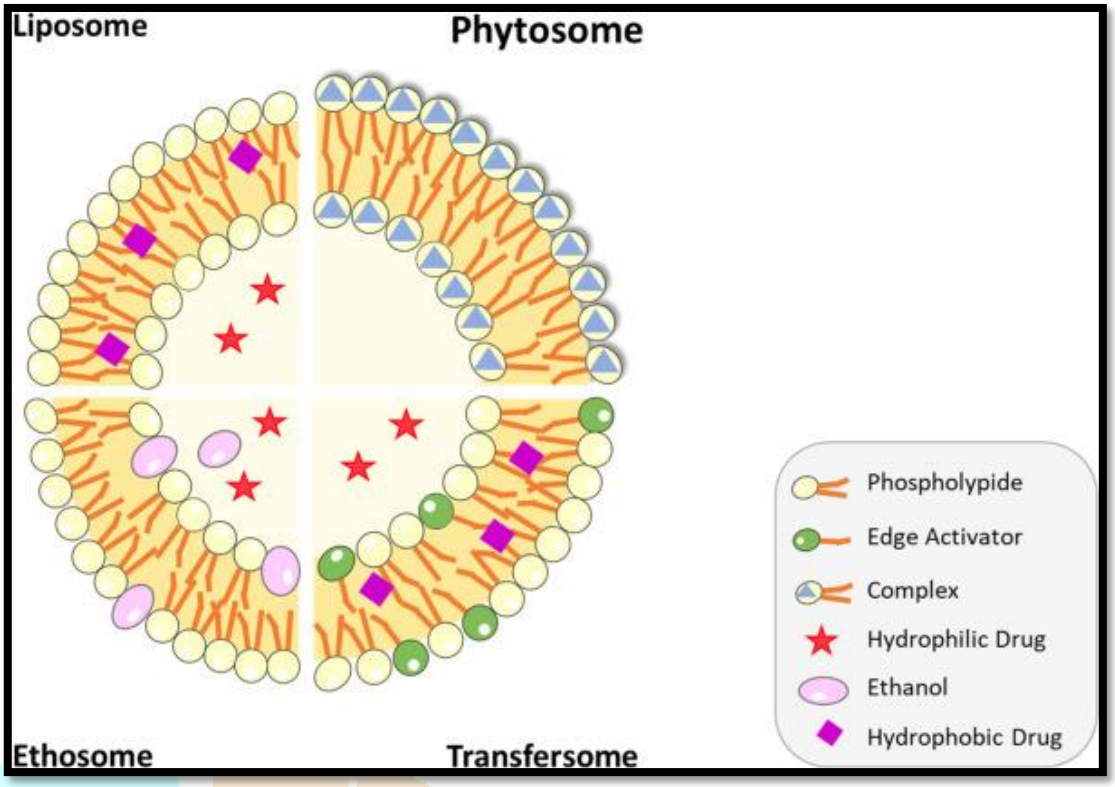

Fig.5.Structure of latest nanocarriers and loading

❖ **Role of Nanotechnology in Improving Herbal Drug Bioavailability**

Herbal medicines often face major limitations such as poor solubility, low permeability, rapid Metabolism, and instability in the gastrointestinal tract, which significantly reduce their therapeutic Efficacy. Nanotechnology provides advanced delivery platforms that overcome these challenges By enhancing the absorption, distribution, and sustained release of herbal phytoconstituents (9)Nanocarriers also improve intestinal permeability, enabling herbal molecules to cross epithelial Tight junctions and avoid first-pass metabolism. Surface-modified nanocarriers, especially those Coated with chitosan or PEG, exhibit enhanced mucoadhesion and prolonged gastrointestinal Residence time, thereby improving absorption efficiency. Some systems additionally employ Pglycoprotein inhibition, allowing nanoherbal drugs to bypass efflux pumps that normally reduce Drug uptake**.(12).**

❖ **Challenges in Nanoformulation and Characterization**

The liver rapidly eliminates the particles within 200–400nanometers, whereas materials that are between 150 and 300 nanometers in size are usually Found in the liver and spleen Therefore, one of the most important steps in producing an effective nanoherbal mixture is particle Size optimization. Surface features also have big impact on how nanoparticles behave and interact With proteins and organelles .**(13).**

❖ **Health Implications of Nanoparticles:**

Nanoparticles' Effects on Health :

Even though there may be a wide range of potential uses for nanopharmaceuticals in the Dispensing of medications for the diagnosis and treatment of various ailments, it is crucial to Understand the hazards involved with employing them .**(14,15).**

- **Respiratory Effects:**

When inhaled, nanoparticles can reach deep into the lungs, even entering alveoli and crossing into The bloodstream.Possible health concerns include:Lung inflammation and irritation.Oxidative stress Exacerbation Of asthma or chronic obstructive pulmonary disease (COPD)Fibrosis with long-term exposure (depending on material) **(16,17).**

- **Skin Effects:**

Nanoparticles used in cosmetics, sunscreens, and personal-care products can interact with the skin.Most do not penetrate deeply, but risks may include:Irritation of sensitive or damaged skinPenetration via wounds or compromised skin layersLong-term accumulation concerns (still being researched).**(18,19).**

❖ Conclusion:

The multidisciplinary development of nanotechnology is hastening the creation of the nearly Impossibly compact gadget. Herbal extracts for medicinal purposes have been recognized for Having fewer negative impacts and are commercially Accepted globally. Nanotechnology is rapidly advancing and enabling highly compact, effective drug delivery systems. Herbal extracts, known for fewer side effects and global acceptance, benefit greatly from nanoformulation, which improves their bioavailability and therapeutic performance. Strengthened national regulations and WHO guidelines on the safety, quality, and efficacy of medicinal plants further support their growing role in modern healthcare.

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