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Applications of Herbal Based Pharmaceutical Nanoparticles: *Averrhoa carambola* L.

[*]M.SaravanaKumar, D. Dhachinamoorthi., B. Premkumar., Anbu selvam E., Fathima Nazeerin.M., Harisundar.A., Shibil Hadi.V., Shibila.T

Department of Pharmaceutics, Sree Abirami College of Pharmacy, Coimbatore 641021, Affiliated to The Tamil nadu Dr MGR Medical University, Chennai, Tamil Nadu. India.

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ABSTRACT

Nanotechnology has instigated profound developments among herbal medicine regarding bioavailability, stability, and therapeutic efficacy. This review deals with nano-herbal formulations preparation, applications, and therapeutic capabilities for medical problems and foods like food packaging and preservation. The formulations are developed using advanced nanotechnology techniques, such as solvent evaporation, nano emulsion formation, and encapsulation. Phytosomes, liposomes, nanocapsules, and nanoemulsions have ensured that bioactive ingredients' stability has been secured, bioavailability and targeted administration have been improved, and negative side effects have been cut considerably. The ability of nanoherbal formulations to deliver drugs to tumor cells in an improved permeability and retention manner, such as, cancer therapy while minimizing tissue damage, has been largely practiced in many laboratories. Enhanced drug solubility, distribution to the site of interest, and successful therapeutic outcomes have had a major impact on inflammatory disorders, Nanocarriers increase the absorption of curcumin and resveratrol, decreasing oxidative stress and improving cardiac function. Nanotechnology has used such reinforcing materials to improve the performance of protective food packages and, consequently, ensure their longer service time. On the one hand, antimicrobial and antioxidant herbal nanoparticles will prevent spoilage and degradation during storage. Nanotechnology and herbal medicine join forces and form a potent medical and nutritional solution to various diseases, food production, and conservation.

Keywords: Herbal medicine, Bioavailability, Nanocarriers, Nano herbal, Nanoparticles, Averrhoa carambola L

INTRODUCTION

Pharmaceutical nanoparticles, ranging from 1 to 1000 nm, are advanced drug delivery systems designed to improve therapeutic outcomes by enhancing drug solubility, stability, and bioavailability. They enable targeted, controlled, and sustained release of medication to specific tissues, reducing systemic toxicity. Key applications include cancer therapy, Gene therapy, vaccine delivery, and antimicrobial agents. Nanotechnology has been increasingly applied to enhance the effectiveness of herbal medications, addressing key challenges such as poor solubility, low bioavailability, and limited therapeutic efficacy. Thus, nanoscale drug delivery systems are used through polymeric nanoparticles, solid lipid nanoparticles, and nanostructured lipid car riers, and the active ingredients are protected, stabilized, and released subsequently. These systems have demonstrated substantial potential in treating chronic diseases, enhancing the therapeutic effects of herbal remedies, and expanding their applications across healthcare and the food industry.

Materials and Methods

Materials

Fresh, unripe Averrhoa carambola (star fruit) was purchased from the South Indian Agri Farm, Mannuthy, Thrissur, Kerala, India regions.

Fig 1: Represents the fruits of *Averrhoa carambola* L.

Methods

Nanoparticles made from herbal extracts use a process called nano precipitation. This improves how well the body can absorb the herbs and how well they work. First, the bioactive chemicals or herbal extracts are dissolved in a solvent that mixes with water. Solid lipid nanoparticles (SLNs) are becoming increasingly popular due to their ability to transport herbal extracts effectively. The nano particles, with sizes ranging from 50 to 1000 nm, consist of biocompatible and biodegradable lipids. This makes them well-suited to transporting different chemicals. The preparation of SLNs in corporates emulsification-hot melt homogenization and ultrasonication to produce stable particles ideal for delivering drugs. Nanostructured lipid carriers (NLCs) have become a promising drug delivery system for herbal formulations. The method of incorporating herbal actives into NLCs in volves specific techniques and considerations. Advanced delivery technologies like herbal nanohydrogels use nanotechnology to improve herbal chemical solubility, activity, and dispersion for numerous therapeutic uses. These nanogels improve herbal drug efficacy and absorption. Drug delivery is ideal for nanogels, tiny crosslinked polymer networks that absorb water.

Improving medication efficacy. In pharmaceuticals, herbal nanogels show potential for treating cancer, skin diseases, and diabetes. Chitin, chitosan, PLGA, PEG, and other polymers make nanogels. These polymers enable skin-applied medicine delivery with fewer side effects than oral pharmaceuticals. Herbal nanogels use nanotechnology to turn natural chemicals into effective medicines, improving patient adherence and safety.

Discussion

Nanotechnology improves herbal bioactive chemical absorption, stability, and targeting for viral illness treatment. Green synthesis of herb-based nanoparticles is eco-friendly and less hazardous than chemical production. Nanocarrier systems boost the antiviral effects of plant-based extracts including neem, turmeric, and green tea in these nanoparticles. Silver nanoparticles made from herbal extracts reduce viral multiplication and boost immunity. Nanotechnology's precision in targeting viral infections is a major benefit. Liposomes, dendrimers, and polymeric nanocarriers manage active chemical release at infected areas, reducing systemic side effects. This method works well for drug resistant virus strains where usual therapy fail. Researchers have recently become interested in the use of herbal extracts for the synthesis of nanoparticles. This method has several ad vantages, including a biocompatible stabilization procedure, fast synthesis, and achieving desired morphologies. Biomolecules facilitate the reduction of metal ions throughout the preparation process.

Conclusion

The integration of nanotechnology with herbal medicine which is the solution to the shortcomings such as the low absorption, instability, and non-targeted delivery in traditional formulation. Nano herbal systems such as liposomes, nano capsules, and nano emulsions offer the therapeutic efficacy and bioavailability of herbal compounds that is due to the fact that they are delivering target sites that are very precise and stable. These innovations are demonstrating the potential in areas such as cancer treatment where they utilize the EPR valve which opens the microcirculation to allow the drugs to get the tumours and in dermatology, they improve the stability and releasing properties of the drugs. Furthermore, nano herbal formulations in the food industry provide more potent delivery of bioactive compounds that not only have nutritional but also functional benefits. Experiments in nano-herbal formulation and optimization facilitated by AI and ML will likely make things faster. Integrating nanotechnology into herbal medicine demands worldwide regulatory norms and sound safety assessments. Nanotechnology could be the game changer for herbal medicine, but researchers, politicians, and industry stakeholders must come together and beat these obstacles.

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 **Author -2**	Author Name : Dr. D. Dhachinamoorthi Affiliated to: The Tamil nadu Dr MGR Medical University, Chennai, Tamil Nadu. India Author Address/Institute Address : Sree Abirami College of Pharmacy, L&T Bypass, Coimbatore - 21 Tamil Nadu, India.
 **Author -3**	Author Name :Dr. B. Premkumar Affiliated to: The Tamil nadu Dr MGR Medical University, Chennai, Tamil Nadu. India Author Address/Institute Address : Sree Abirami College of Pharmacy, L&T Bypass, Coimbatore - 21 Tamil Nadu, India.
 **Author -4**	Author Name : Anbu selvam E Affiliated to : The Tamil nadu Dr MGR Medical University, Chennai, Tamil Nadu. India Author Address/Institute Address : Sree Abirami College of Pharmacy, L&T Bypass, Coimbatore - 21 Tamil Nadu, India.
Image Author -5	Author Name : Fathima Nazeerin.M Affiliated to: The Tamil nadu Dr MGR Medical University, Chennai, Tamil Nadu. India Author Address/Institute Address : Sree Abirami College of Pharmacy, L&T Bypass, Coimbatore - 21 Tamil Nadu, India.