OPEN ACCESS Freely available online

Medicinal & Aromatic Plants

ISSN: 2167-0412

Commentary

Nanoformulations of Medicinal Plant Extracts for Enhanced Bioavailability and Targeted Therapy

Neha Iqbal*

Department of Pharmacognosy, Al-Ameen College of Pharmacy, Bangalore, India

DESCRIPTION

Medicinal plants have long served as rich reservoirs of pharmacologically active compounds. However, the clinical translation of many herbal medicines remains restricted due to poor solubility, low stability, rapid degradation in the gastrointestinal tract and low bioavailability. The gap between traditional knowledge and modern pharmaceutical demand, the integration of nanotechnology into herbal medicine specifically the development of nanoformulations has emerged as a promising strategy.

Nanoformulations, including nanoparticles, nanoemulsions, liposomes and phytosomes, offer a way to overcome many of the limitations associated with conventional herbal delivery systems. These nanocarriers can encapsulate plant-derived bioactive compounds, protecting them from enzymatic and chemical degradation while also enhancing solubility and systemic absorption. The controlled and sustained release profiles associated with nanoformulations also contribute to more consistent pharmacokinetics, potentially reducing dosing frequency and improving therapeutic outcomes.

A major advantage of using nanoformulations is the significant improvement in bioavailability. Many phytochemicals, such as curcumin, quercetin and resveratrol, have excellent therapeutic potential but suffer from poor absorption and rapid systemic elimination. Encapsulating such molecules in nanoscale carriers enhances their dissolution rate and cellular uptake. For example, curcumin-loaded nanoparticles have demonstrated higher plasma concentrations and longer circulation times compared to free curcumin, making them more efficacious in preclinical models of cancer, inflammation and neurodegeneration.

In addition to bioavailability, targeted delivery is another key benefit of nanoformulations. Unlike conventional administration methods, which often result in non-specific distribution and systemic side effects, nanocarriers can be functionalized with ligands that bind to specific receptors overexpressed on diseased cells, such as tumor or inflamed tissues. This targeted approach not only enhances drug accumulation at the desired site but also minimizes toxicity to healthy tissues. For instance, folate-conjugated liposomes loaded with plant-derived anticancer agents have shown enhanced uptake by cancer cells, leading to greater cytotoxicity in tumor tissues without harming normal cells.

Furthermore, nanoformulations allow for multifunctionality. It is possible to co-load multiple phytochemicals or combine herbal actives with synthetic drugs in a single carrier, offering synergistic effects that could enhance therapeutic efficiency. This strategy could be especially valuable in treating complex diseases like cancer or diabetes, where multiple pathways must be targeted simultaneously.

Despite the evident promise, challenges persist. One concern is the lack of standardized protocols for preparing and characterizing herbal nanoformulations. The heterogeneity of plant extracts containing numerous active and inactive constituents complicates the formulation process and may affect reproducibility. Moreover, regulatory pathways for herbal nanomedicines remain underdeveloped in many countries. The classification, safety evaluation and approval of such complex systems require clear frameworks to ensure public trust and scientific integrity.

Another significant concern lies in toxicity and long-term safety. While nanocarriers can improve delivery, they may also introduce risks due to their small size and surface activity. It is essential to assess the biocompatibility of both the carrier materials and the encapsulated herbal compounds under *in vivo* conditions. Moreover, the fate of these nanocarriers whether they are fully metabolized or accumulate in specific organs needs to be studied systematically.

From an industry standpoint, scalability and cost-effectiveness remain important considerations. Although laboratory-scale nanoformulation methods are well established, transitioning these technologies to commercial production while maintaining quality and consistency is a non-trivial task. Furthermore, herbal extracts vary significantly depending on plant origin, harvesting season and extraction methods, making standardization even more challenging.

Correspondence to: Neha Iqbal, Department of Pharmacognosy, Al-Ameen College of Pharmacy, Bangalore, India, E-mail: nehaiqbal.pharma@biomeduni.in

Received: 16-May-2025,Manuscript No. MAP-25-37790 **Editor assigned:** 19-May-2025,PreQC No. MAP-25-37790 (PQ);**Reviewed:** 02-Jun-2025, QC No. MAP-25-37790; **Revised:** 09-Jun-2025, Manuscript No. MAP-25-37790 (R); **Published:** 16-Jun-2025, DOI: 10.35248/2167-0412.24.14.510

Citation: Iqbal N (2025) Nanoformulations of Medicinal Plant Extracts for Enhanced Bioavailability and Targeted Therapy. Med Aromat Plant. 14:510.

Nonetheless, the future of nano-herbal formulations appears promising, especially with the growing emphasis on personalized medicine and integrative approaches to healthcare. Nanotechnology provides an elegant and efficient means of delivering plant-derived bioactives in a manner that aligns with modern pharmacological requirements. As research continues to evolve, collaborations between phytochemists, nano-technologists, pharmacologists and regulatory bodies will be key to unlocking the full potential of this interdisciplinary field.

Nanoformulations represent a significant advancement in the delivery of medicinal plant extracts. By improving bioavailability, enabling targeted delivery and offering multifunctional capabilities, they hold the potential to transform herbal medicine into more clinically viable therapeutic options. However, to ensure their successful integration into mainstream healthcare, robust scientific validation, safety assessment and regulatory clarity must accompany the technological innovation.