Developing and Evaluating Rosemary Essential Oil Nanosystems: Enhancing Stability and Antioxidant Efficacy

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Nano-techniques offer innovative solutions to improve the delivery and efficacy of bioactive compounds such as rosemary essential oil (REO), which is valued for its antioxidant, antimicrobial, and anti-inflammatory properties. Due to its low water solubility and chemical instability, REO's practical use remains limited. This study explores the design and development of lipid-based nanocarriers, specifically nanoemulsions and liposomes, to enhance the stability, bioavailability, and controlled release of REO.

Nanoemulsions were produced using high-pressure homogenization, generating stable nano-sized droplets, while liposomes were fabricated via ethanol injection, employing phospholipids from Lipoid S75, PC3, and S100 to optimize encapsulation efficiency and membrane fluidity. Physicochemical characterization revealed that nanoemulsions and liposomes with Lipoid S75 and PC3 exhibited smaller particle sizes (<150 nm), higher encapsulation efficiency (>85%), and better antioxidant retention compared to liposomes made with Lipoid S100.

Storage stability tests at 4°C and 25°C confirmed that REO-loaded nanoemulsions and liposomes maintained their physicochemical properties and antioxidant activity over time, effectively protecting REO from oxidative degradation. These results highlight the critical role of lipid composition and nanoformulation method in enhancing delivery system performance.

Overall, this study demonstrates that lipid-based nanoformulations, particularly those using unsaturated phospholipids, represent promising platforms for improving the therapeutic potential of rosemary essential oil in pharmaceutical and industrial applications.

Keywords: Rosemary essential oil, nanoemulsions, liposomes, lipid-based delivery systems, stability

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