Development of Lipid-Based Nanocarriers Encapsulating Eucalyptus Officinalis Essential Oil: Comparative Evaluation of Liposomes and Nanoemulsions

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Eucalyptus officinalis essential oil is recognized for its antimicrobial, antioxidant, anti-inflammatory, analgesic, and expectorant properties. However, its clinical and industrial application is restricted due to poor aqueous solubility, high volatility, and chemical instability when exposed to light, oxygen, or heat, which compromise its bioavailability and shelf life. To address these challenges, lipid-based nanocarriers were developed: liposomes (LS) formulated with Lipoid® S100 and oil-in-water nanoemulsions (NE) prepared by high-pressure homogenization. Formulations containing *Eucalyptus officinalis* essential oil (0.5–5 mg/mL) were stored at 4 °C and 25 °C and characterized by dynamic light scattering. Both LS and NE displayed particle sizes of 80–120 nm, low polydispersity index values (<0.2), and highly negative zeta potentials (–38 to –47 mV), confirming homogeneous dispersions and good colloidal stability. Encapsulation efficiency (EE%) reached 73–82% for NE (optimal at 2.5–5 mg/mL at 4 °C) and 77–84% for LS, with maximum values at 5 mg/mL at 4 °C. Storage at 4 °C consistently preserved smaller particle sizes, narrower distributions, and stronger electrostatic stabilization compared to 25 °C, indicating improved stability under refrigeration. Overall, liposomes provided slightly higher encapsulation efficiency, whereas nanoemulsions offered better uniformity and electrostatic stabilization.

Keywords: *Eucalyptus officinalis*, lipid-based nanocarriers, liposomes, nanoemulsions, high-pressure homogenization, encapsulation efficiency, stability.

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