Development of Phospholipid-Based Nanoparticles Encapsulating Carvacrol and Thymol: Influence of Lipid Composition on Size, Stability, and Encapsulation Efficiency

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Phenolic compounds such as carvacrol and thymol are well known for their broad-spectrum biological activities, including antimicrobial, antioxidant, and anti-inflammatory effects. However, their low aqueous solubility and instability present significant challenges for effective delivery. This study explores the development and physicochemical characterization of nanoscale phospholipid-based carriers to enhance the biological potential of these compounds. Using three Lipoid® phospholipids (85G, PC-3, and S-75), nanocarriers were prepared with varying payloads (1, 2.5, and 5 mg/mL), and characterized for particle size, polydispersity index (PDI), and zeta potential (ZP) via dynamic light scattering. Encapsulation efficiency (EE%) was assessed spectrophotometrically. Among the formulations, S-75-based nanocarriers demonstrated the most favorable properties for biological application, with particle sizes of 82–92 nm, low PDI (< 0.24), highly negative ZP (–41 to –49 mV), and EE% reaching 90.2% for carvacrol. Similar results were observed with thymol, indicating a consistent formulation profile. In contrast, PC-3 showed poor stability at higher payloads, and 85G yielded intermediate characteristics. The high encapsulation efficiency and stability of S-75 formulations highlight their potential as effective delivery platforms to enhance the biological efficacy of phenolic compounds. These nanosystems offer a promising strategy for the application of natural bioactives in pharmaceutical, nutraceutical, and food-related fields.

Key words: carvacrol, thymol, nanosystems, phospholipids, encapsulation efficiency

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