Delivery of Curcumin-Loaded Polymeric Nanoparticles in Granulates for Oral Administration

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Abstract:

Turmeric (Curcuma longa Linn) possesses strong antimicrobial, anti-inflammatory, anticancer, and immunomodulatory properties, attributed primarily to its curcuminoids: curcumin (CUR), dimethoxycurcumin (DMC), and bisdemethoxycurcumin (BDMC), which, combined, are more effective than the individual molecules, suggesting a synergistic effect. However, their therapeutic use is limited by poor oral and parenteral bioavailability, resulting from low water solubility, rapid degradation at neutral-alkaline pH, limited tissue absorption, and rapid systemic clearance.

To address these limitations, PMDA polymer nanoparticles were prepared for the encapsulation of curcuminoids via direct nanoprecipitation, specifically for oral administration. The nanoparticles had an average size below 100 nm and a ζ potential of −40 mV, remaining stable after being incorporated into oral granules. HPLC analysis showed a drug loading of 5.1 ± 0.8% and an encapsulation efficiency of 53 ± 4%.

To evaluate the properties of the nanoparticles under administration conditions, an oral solid form was formulated to contain ~90 µg of curcumin, corresponding to 1.78 mg of loaded nanoparticles.

Dissolution tests according to the United States Pharmacopeia (USP 48) were performed to evaluate the released profile of the curcumin. Free curcumin reached complete release within 120 minutes. Nanoparticles exhibited a rapid initial burst (~49% in 5 minutes), which then remained constant for the duration of the test, indicating strong entrapment within the polymeric matrix. The oral formulation improved dispersion and wettability of the nanoparticles, achieving ~60% release within 5 minutes, which also remained stable throughout the test, likely due to enhanced surface area and accessibility of the readily releasable curcumin fraction.

Moreover, the stability of nanoparticles under gastrointestinal pH conditions and their cytocompatibility were evaluated to fully validate their suitability for oral administration.