

Unexplored and Emerging Formulations of Moringa oleifera: Opportunities and Challenges in Nutraceutical Development

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Abstract: *Moringa oleifera*, popularly known as the "miracle tree," has emerged as a promising candidate for nutraceutical study because of its high nutritional and phytochemical content. *M. Oleifera* contains approximately 110 bioactive chemicals, including flavonoids, phenolic acids, glucosinolates, alkaloids, terpenoids, and sterols, which provide a variety of health benefits such as antioxidant, anti-inflammatory, antidiabetic, hepatoprotective, cardioprotective, and neuroprotective effects. Traditional formulations, such as powders, teas, and capsules, have limitations due to poor solubility, low bioavailability, short shelf life, and disagreeable taste or odour. To address these issues, innovative formulations such as nanoparticles, nanoemulsions, oral thin films, hydrogels, biopolymer-based encapsulation, spray-dried powders, and functional meals have been investigated for improved bioavailability, stability, and patient compliance. Furthermore, topical and transdermal applications of *Moringa* extracts in creams, gels, and films offer new opportunities in the cosmetic and dermatological domains. Beyond its therapeutic applications, *M. Oleifera* shows potential in tailored nutrition, pediatric and geriatric formulations, and long-term nutraceutical creation via byproducts. However, challenges such as variability in phytochemical content, a lack of large-scale clinical trials, safety concerns, regulatory hurdles, and supply chain sustainability have yet to be tackled. This review critically examines *M. Oleifera*'s phytochemistry, therapeutic properties, current and novel delivery modes, and future prospects, highlighting both opportunities and challenges in adapting its traditional use to modern nutraceutical advances.

Keywords: *Moringa oleifera*, Phytochemicals, Nutraceutical formulations, Antioxidant activity, Bioavailability enhancement

