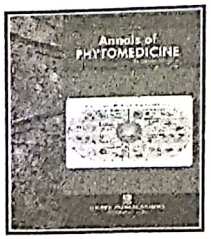
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Sinigrin: A next-generation bioactive compound for pharmaceutical and industrial applications

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Abstract

Sinigrin, a prominent aliphatic glucosinolate predominantly found in Brassicaceae species, has gained increasing attention due to its diverse biological activities and industrial relevance. This review provides a comprehensive overview of sinigrin, covering its natural sources, chemical structure, physicochemical properties, biosynthesis, metabolism, pharmacological activities and industrial applications. Sinigrin is widely distributed in plants such as *Brassica nigra*, *Brassica juncea*, *Brassica oleracea* and *Armoracia rusticana*, with its content influenced by genetic, environmental and processing factors. Structurally, sinigrin is characterized by a thioglucoside linkage and a sulfate group, which contribute to its high polarity and reactivity. The biological activity of sinigrin is primarily attributed to its enzymatic hydrolysis product, allyl isothiocyanate, which plays a key role in mediating its pharmacological effects. These include anticancer, antimicrobial, anti-inflammatory, antioxidant, antidiabetic, cardioprotective and neuroprotective properties, largely through modulation of cellular signaling pathways such as Nrf2, NF-κB and MAPK. The review also highlights the importance of sinigrin metabolism and bioavailability, emphasizing the role of myrosinase and gut microbiota in its activation. In addition to its health benefits, sinigrin has significant industrial applications. It is widely used as a natural flavoring agent, antimicrobial preservative in food systems, biofumigant in agriculture and functional ingredient in pharmaceutical and cosmetic formulations. However, challenges such as instability, low bioavailability, variability in natural sources and difficulties in standardization limit its full exploitation. Emerging approaches, including nanotechnology-based delivery systems and metabolic engineering, offer promising solutions to enhance its stability and efficacy.

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