

A New Horizon in Neuropharmacology Recent Advances in Natural Products Research for Crossing the Blood – Brain Barrier

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Abstract

The blood-brain barrier (BBB) presents a formidable challenge for delivering therapeutics to the central nervous system (CNS), impeding the efficacy of many potential treatments for neurological disorders. Recent research has increasingly focused on natural products as promising candidates for overcoming this barrier. This article reviews recent advances in natural products research, highlighting how compounds derived from plants, fungi, and microorganisms have demonstrated the ability to cross the BBB. Key mechanisms facilitating this include molecular size, lipophilicity, active transport, and receptor-mediated uptake. Notable examples include curcumin, resveratrol, ginsenosides, and epigallocatechin gallate (EGCG), which have shown neuroprotective and therapeutic potential. The article also explores advancements in drug delivery systems, such as nanoparticles, that enhance the bioavailability of these natural compounds. Despite significant progress, challenges such as bioavailability, stability, and safety remain. Future research will focus on optimizing delivery methods and understanding the mechanisms of action to fully harness the therapeutic potential of natural products in treating CNS diseases.

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Many natural products with BBB-crossing potential are small molecules that exhibit high lipophilicity, which facilitates their passage through the lipid-rich BBB. For instance, curcumin, a polyphenol derived from turmeric, is known for its anti-inflammatory and neuroprotective properties [7]. Its ability to cross the BBB is attributed to its lipophilic nature, allowing it to diffuse through the endothelial cell membranes.

A

Some natural products can utilize existing transport mechanisms in the BBB. For example, certain flavonoids and glycosides may be substrates for specific transporters, enabling their entry into the CNS [8]. Quercetin, a flavonoid found in various fruits and vegetables, has shown promise in enhancing BBB permeability through interactions with transport proteins.

R

Natural products that bind to specific receptors on the BBB can be transported across the barrier. For example, berberine, an alkaloid from *Berberis* species, has been demonstrated to cross the BBB via receptor-mediated endocytosis. This mechanism allows berberine to exert neuroprotective effects by targeting neuronal receptors and signaling pathways.

M

Advances in nanotechnology have facilitated the development of nanoparticle-based delivery systems that can transport natural products across the BBB. Nanoparticles can encapsulate bioactive natural compounds, enhancing their stability, bioavailability, and BBB penetration [9]. For example, nanoparticles loaded with ginseng extracts have been shown to improve cognitive function in preclinical models by effectively delivering ginsenosides to the brain.

R

C

Curcumin, derived from turmeric, has been extensively studied for its potential neurotherapeutic benefits. Research has demonstrated that curcumin can cross the BBB and exhibit anti-inflammatory and antioxidant effects in the CNS. Recent studies have focused on improving curcumin's bioavailability and BBB penetration through formulation strategies such as nanoparticles and liposomal delivery.

R

Resveratrol, a polyphenol found in grapes and red wine, is another natural product with notable neuroprotective properties [10]. Its ability to cross the BBB has been attributed to its small molecular size and lipophilicity. Recent research has explored resveratrol's potential in treating neurodegenerative diseases such as Alzheimer's disease, with promising results in preclinical models. Ginsenosides, the active components of ginseng, have shown potential in crossing the BBB and exerting neuroprotective effects. Recent advancements have involved developing novel delivery systems, such as nanoparticles and liposomes, to enhance the bioavailability and efficacy of ginsenosides in the CNS.

E

EGCG, a major catechin in green tea, has demonstrated the ability to cross the BBB and exhibit neuroprotective and anti-inflammatory effects. Recent studies have focused on optimizing EGCG formulations

to improve its stability and brain penetration, with the goal of developing effective therapies for neurodegenerative diseases.

D

Ensuring the stability and bioavailability of natural products in the CNS remains a significant challenge. Advances in drug delivery systems, such as nanoparticles and liposomes, are essential for overcoming these issues and improving the therapeutic efficacy of natural products.

a

Comprehensive safety and efficacy evaluations are crucial for translating natural product research into clinical applications. Rigorous preclinical and clinical studies are necessary to assess the long-term effects and potential side effects of natural products used in neurotherapeutics.

M

A deeper understanding of the mechanisms by which natural products cross the BBB and interact with CNS targets is essential for optimizing their use. Continued research into the pharmacokinetics and pharmacodynamics of these compounds will help refine their therapeutic applications.

C

The exploration of natural products for their ability to cross the blood-brain barrier represents a promising frontier in neuropharmacology. Recent advances have highlighted the potential of compounds such as curcumin, resveratrol, ginsenosides, and EGCG in overcoming the challenges of BBB penetration and offering therapeutic benefits for neurological disorders. By leveraging the unique properties of natural products and employing innovative delivery systems, researchers are paving the way for the development of novel treatments that could significantly impact the management of CNS diseases. Continued research and technological advancements will be crucial in realizing the full potential of natural products in neurotherapeutics, offering new hope for effective treatments in neurology and beyond.

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None

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None

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