Chapter 5

The Therapeutic Role of Secondary Metabolites in Neurodegenerative and Inflammatory Diseases, Mechanisms, and Potential Applications

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ABSTRACT

Secondary metabolites, bioactive compounds from plants, fungi, and microorganisms, show significant therapeutic potential for neurodegenerative and inflammatory diseases. This chapter highlights their mechanisms of action, including antioxidant activity, modulation of inflammatory pathways, and neuroprotection, supported by preclinical and clinical evidence. Key classes like alkaloids, flavonoids, terpenoids, and polyphenols are explored for their neuroprotective and anti-inflammatory properties, alongside phytochemical sources that emphasize their drug discovery potential. However, challenges such as limited bioavailability, stability, and toxicity hinder their clinical application. Addressing these issues through novel strategies could unlock their full potential in modern medicine. This chapter bridges natural product chemistry and clinical applications, providing insights to inspire further research into secondary metabolites as essential tools for combating complex diseases.

1. INTRODUCTION

Secondary metabolites are a diverse class of bioactive compounds synthesized by various organisms, including plants, microorganisms, and certain marine species, (Bills & Gloer, 2016) (Jain, Khatana, & Vijayvergia, 2019). While not essential for primary metabolic processes, these molecules play critical roles in environmental adaptation, biological defense, and interspecies interactions, (Mérillon & Ramawat, 2020) (Kumar *et al.,* 2023). Specialized metabolic pathways, resulting in a broad chemical diversity that includes alkaloids, polyphenols, flavonoids, and terpenoids, drive their biosynthesis. These compounds, often specific to particular species or families, represent valuable sources for the discovery of novel bioactive molecules, (Laadraoui *et al.,* 2018) (Guerriero *et al.,* 2018). Medicinal plants, in particular, serve as a major source, while microorganisms and aquatic organisms offer emerging opportunities in this field, (Luckner, 2013). The diversity of these natural products highlights their potential for uncovering new therapeutic agents, (Yang *et al.,* 2025).

Beyond their ecological roles, secondary metabolites have significant industrial relevance, (Azizan *et al.,* 2016). They play a crucial role in pharmaceutical research and production due to their ability to modulate biological processes in humans and animals, (Bourgaud *et al.,* 2001) (Bafor, 2017). Furthermore, their applications extend to other industries, including cosmetics, nutrition, and the manufacturing of industrial goods such as dyes, fragrances, flavors, and dietary supplements, (Bermudez-Torres *et al.,* 2013) (Gainche, 2020). This wide range of uses underscores their economic and scientific importance.

ADHD and Addiction: A Story of Complex Interaction and Interphase

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