



Mini Review

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Unlocking the Potential of *Dryopteris juxtapostia*: Novel Bioactive Applications, Green Extraction Trends, and Future Prospects

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Abstract

Dryopteris juxtapostia (DJ) is a promising source of bioactive compounds with diverse applications in medicine, agriculture, and biotechnology. Despite extensive phytochemical profiling, critical knowledge gaps exist regarding the scalability of bioactive extraction, advanced formulation techniques for enhanced efficacy, and its integration into nanomedicine and sustainable agriculture. This mini-review explores innovative green extraction methods, novel applications of DJ bio actives, and their potential in emerging industries, addressing existing research gaps and offering new perspectives for future studies.

Keywords: Tannin-rich extracts; Edible coatings; Biodegradable films; Bioactive compounds; Natural preservatives

Abbreviations: DJ: *Dryopteris juxtapostia*, HPHE: High-Performance Hybrid Extraction, UAE: Ultrasound-Assisted Extraction, SFE: Supercritical Fluid Extraction, MAE: Microwave-Assisted Extraction, EAE: Enzyme-Assisted Extraction

Introduction

Ferns of the *Dryopteris* genus are widely studied for their medicinal properties, yet DJ remains relatively underexplored in the context of biopharmaceutical formulations, eco-friendly pesticides, and functional food applications [1]. While traditional uses of DJ focus on its antimicrobial and antioxidant properties, emerging biotechnological innovations suggest broader applications that remain largely uninvestigated. This review identifies three key gaps in current research: (1) optimizing green extraction for industrial-scale applications, (2) enhancing bioavailability via nanotechnology, and (3) repurposing DJ bio actives in novel biomedical and agricultural sectors [2].

Advanced Green Extraction Techniques for DJ Bio actives

High-Performance Hybrid Extraction (HPHE)

Conventional green extraction methods such as ultrasound-assisted extraction (UAE), supercritical fluid extraction (SFE), and microwave-assisted extraction (MAE) have been explored

for extracting bioactives from DJ. However, emerging research indicates that a hybrid approach, which integrates UAE with enzyme-assisted extraction (EAE), significantly enhances bioactive recovery [3]. This novel technique, known as HPHE (Hybrid Process for High Efficiency), combines ultrasound cavitation for cell disruption, enzymatic hydrolysis to improve compound solubility, and supercritical CO₂ processing for selective extraction. By reducing solvent use, HPHE can increase yield by up to 40% while preserving sensitive bio actives such as flavonoids and sterols [4].

Nanoencapsulation for Enhanced Stability and Delivery

One of the biggest challenges with DJ bioactives is their low bioavailability. Polyphenols and flavonoids, though potent, degrade rapidly in physiological conditions. Lipid-based nanoencapsulation (e.g., liposomes and phytosomes) significantly enhances their absorption [5]. Recent advances in chitosan-based nanoparticles have demonstrated a 3-fold increase in flavonoid stability, paving the way for DJ-derived nutraceuticals and targeted drug delivery [6].

Innovative Applications of *DJ* Bio actives

Functional Foods & Bioactive Packaging

Tannin-rich extracts from *DJ* have shown promise in the development of edible coatings, as they can be incorporated into biodegradable films to extend fruit shelf life by 30% while effectively inhibiting fungal growth [1,7]. Additionally, flavonoids derived from *DJ* have been identified as potential modulators of the gut microbiome, promoting beneficial gut bacteria and suggesting applications in probiotic formulations [8].

DJ in Next-Generation Biopesticides

The unique flavonoid-terpenoid complex in *DJ* demonstrates broad-spectrum antifungal activity that sets it apart from traditional pesticides. These compounds operate through several mechanisms, including enzyme inhibition, which disrupts fungal cell wall biosynthesis, and the induction of oxidative stress, preventing pathogen colonization. Additionally, they exhibit a synergistic effect with plant microbiomes, enhancing soil health. Field trials utilizing *DJ*-based biopesticides have shown a remarkable 45% reduction in fungal crop infections, highlighting their significant promise for organic farming [1,9].

DJ as a Biopharmaceutical Candidate

Preliminary animal studies indicate that polyphenols derived from *DJ* significantly enhance collagen synthesis and reduce wound closure time by 25%, demonstrating their potential in wound healing applications [1,10]. Furthermore, the flavonoids found in *DJ* exhibit promising neuroprotective effects, particularly in their ability to reduce amyloid-beta aggregation, positioning them as potential candidates for research in Alzheimer's disease [11].

Future Prospects and Research Directions

Despite its immense potential, *DJ* remains underutilized due to challenges related to scalability, regulatory approvals, and the lack of standardized extraction protocols. Future research should focus on several key areas to overcome these barriers. First, synthetic biology approaches could be employed to engineer microbial platforms for the biosynthesis of *DJ* compounds [12]. Additionally, integrating AI-driven phytochemical screening could help predict novel bioactivities for pharmaceutical applications, enhancing the discovery process [1,4]. Finally, developing commercialization roadmaps and forging industrial partnerships will be crucial for bringing *DJ*-derived green products to market effectively [13].

Conclusion

DJ holds unparalleled potential in bioactive applications, yet remains largely unexplored beyond traditional uses. By leveraging

hybrid green extraction, nano formulations, and AI-driven bioactivity analysis, *DJ* could revolutionize sustainable agriculture, functional foods, and next-generation medicine. Future studies must focus on scalability and innovative delivery systems to bridge the gap between lab research and real-world applications.

Conflict of Interest

There is no conflict of interest existed.

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