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Editorial

Natural Products: Sources and Applications

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1. Introduction

Natural products have been an essential driver of human advancement, providing unparalleled chemical diversity and a wide range of biological activities. From ancient herbal remedies to cutting-edge modern therapeutics, these bioactive compounds have significantly influenced industries as diverse as medicine, agriculture, and cosmetics [1]. Their origins are equally diverse, encompassing terrestrial plants, microorganisms, and marine life, each offering unique chemical architectures and mechanisms of action that continue to inspire innovations and discoveries [1].

Plants are one of the oldest and most explored sources of natural products. Their secondary metabolites serve not only as defense mechanisms, but also as therapeutic agents for humans. For instance, paclitaxel, derived from the Pacific yew tree (*Taxus brevifolia*), is a critical chemotherapeutic agent [2], while artemisinin from sweet wormwood (*Artemisia annua*) has revolutionized malaria treatment [3]. The cosmetic and personal care industries also benefit immensely from plant-derived products. Shea butter, sourced from *Vitellaria paradoxa* nuts, and *Aloe vera* gel are commonly used for their hydrating and soothing properties in skincare products. Additionally, antioxidant-rich compounds, such as polyphenols from green tea and retinoids from papaya, are key ingredients in anti-aging formulations, offering natural solutions for maintaining youthful and healthy skin [4]. In agriculture, neem oil, extracted from the *Azadirachta indica* tree, contains azadirachtin, a potent natural insect repellent used in organic farming to reduce dependence on synthetic pesticides [5].

Microorganisms have also made invaluable contributions to medicine. Antibiotics like penicillin from *Penicillium rubens* and cephalosporins from the *Acremonium* species have become indispensable in the fight against bacterial infections [6]. Beyond antibiotics, microorganisms have contributed to other therapeutic areas. For instance, cyclosporine A, derived from the fungus *Tolypocladium inflatum*, has revolutionized organ transplantation as a potent immunosuppressant [7]. Similarly, microbial products such as doxorubicin, produced by *Streptomyces peucetius*, and bleomycin, isolated from *Streptomyces verticillus*, are critical anticancer agents used in treating various malignancies [8]. In agriculture, biopesticides derived from microbial sources are increasingly replacing synthetic chemicals, offering environmentally friendly pest control. *Bacillus thuringiensis* (Bt), a bacterium that produces insecticidal proteins, has been widely adopted in organic farming and genetically modified crops to protect against pests [9]. Additionally, nitrogen-fixing bacteria, such as *Rhizobium* species, form symbiotic relationships with legumes, naturally enriching soil fertility and reducing the dependence on chemical fertilizers [10].

Marine organisms represent an extraordinary and relatively recent frontier in natural product research, offering a wealth of bioactive compounds with unique structural features. These compounds have inspired transformative advancements in medicine and industry.

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One notable example is ziconotide, derived from ω-conotoxin in the venom of the marine cone snail *Conus magus*. This innovative compound has been developed into a non-opioid analgesic used to treat severe chronic pain, offering a critical alternative to traditional pain management approaches [11]. Trabectedin, isolated from the tunicate *Ecteinascidia turbinata*, is a prominent anticancer agent used in the treatment of soft tissue sarcomas and ovarian cancer [11]. The contributions of marine organisms extend beyond pharmaceuticals. Bioactive compounds from marine algae and sponges, such as polyketides and alkaloids, are being explored for environmentally sustainable antifouling paints. These innovative materials help prevent biofouling on ship hulls, replacing harmful synthetic chemicals and contributing to marine ecosystem protection [12]. The structural novelty of marine natural products continues to captivate researchers, offering solutions for unmet needs.

In summary, natural products remain a cornerstone of scientific discovery and innovation, providing unparalleled chemical diversity and bioactivity that address critical needs across medicine, agriculture, cosmetics, and environmental sustainability. Their diverse origins—from terrestrial plants to microorganisms and marine life—highlight the immense potential of nature as a source of transformative solutions, ensuring their continued relevance in advancing human health and ecological balance.

2. Overview of Published Articles

This Special Issue of *Applied Sciences*, titled "Natural Products: Sources and Applications", brings together a diverse array of research articles and reviews that reflect the vibrancy and interdisciplinary nature of the field. From advanced bioprospecting techniques to innovative industrial applications, these contributions highlight emerging opportunities and address some of the most pressing challenges in natural product research. Collectively, they underscore the transformative potential of natural products to contribute to science, industry, and society.

The research featured in this Special issue spans several key areas of innovation and exploration, including, comprehensive reviews, phytochemical and bioactivity studies, anticancer innovations, ethnobotany, food processing, and industrial and therapeutic applications. For instance, Aires et al. reviewed the supercritical extraction and bioactivities of *Acrocomia aculeata* oil, emphasizing its rich content of fatty acids, carotenoids, and tocopherols. Their findings highlight its pharmaceutical and food industry applications, achieved through innovative extraction methodologies (contribution 1). Similarly, Buljeta et al. provided an in-depth review of sustainable techniques for extracting dietary fibers from plant-based industry waste, demonstrating their potential in developing functional foods (contribution 2). Rodrigues et al. explored the ethnomedicinal properties of salt-tolerant plants, detailing their neuroprotective effects and potential in treating neurological disorders through cholinesterase inhibition and anti-inflammatory activities (contribution 3).

Several studies in this issue highlight the diverse bioactivities of natural products. For example, *Solanum elaeagnifolium* was analyzed for its chemical composition, demonstrating significant antihyperglycemic, anti-inflammatory, and anti-lipase properties (contribution 4). Similarly, roasting *Handroanthus impetiginosus* was found to enhance its anticancer effects in lung cancer cells, while also improving its antioxidant and anti-inflammatory properties (contribution 5). Research on *Rosa rugosa* roots identified bioactive polysaccharides with potential applications in cosmetics and medicine due to their antioxidant and enzyme-inhibitory effects (contribution 6). Studies on *Thymelaea microphylla* flavonoid-rich extract reveal its antioxidant and nephroprotective properties against drug-induced nephrotoxicity (contribution 7), whereas Silva et al. investigated the antibacterial and antibiofilm potential

of phenolic-rich extracts from *Quercus ilex* and *Quercus suber* acorns, identifying promising applications in the food, pharmaceutical, and cosmetic industries (contribution 8).

Natural products continue to play a critical role in cancer research. *Iberis sempervirens* demonstrated significant antiproliferative effects against lung and bladder cancer cells, attributed to its glucosinolate composition (contribution 9). Similarly, extracts from *Neptunia oleracea* showed potential for managing gastric cancer by suppressing cancer cell proliferation and promoting apoptosis (contribution 10). *Salvia triloba* extracts exhibited synergistic antiproliferative effects when combined with paclitaxel, underscoring their therapeutic potential (contribution 11).

Ethnobotanical studies by Fakchich et al. detailed traditional medicinal practices in Morocco, highlighting the diversity and therapeutic applications of local flora (contribution 12). Alves et al. investigated the effects of food processing on *Ipomoea batatas*, finding that microwave treatment best preserved its antioxidant properties, demonstrating how processing methods impact bioactive retention (contribution 13).

Innovative approaches to industrial and therapeutic uses of natural products were also a focus. For instance, Ayyadurai and Deonikaru demonstrated the synergistic anti-inflammatory effects of apigenin and hesperidin, providing insights for nutraceutical development (contribution 14). Pang et al. demonstrated that membrane-free stem cell extract effectively alleviates atopic dermatitis symptoms in a mouse model, providing a novel approach to managing inflammatory skin conditions (contribution 15). Šišić et al. explored chiral chromatography and biotechnological methods for producing ectoine enantiomers, emphasizing their potential as osmoprotective agents in pharmaceuticals (contribution 16). Additionally, Lee et al. optimized ethanol-based extraction of phycocyanobilin from *Arthrospira maxima*, offering a scalable solution for producing a stable natural blue pigment for food and cosmetics (contribution 17).

3. Conclusions and Prospects

The field of natural products holds immense potential for addressing global challenges in healthcare, agriculture, and sustainability. Future advancements will depend on the integration of advanced technologies, such as artificial intelligence, machine learning, and omics-based approaches, to accelerate the discovery and optimization of bioactive compounds. Additionally, synthetic biology and biotechnological innovations offer sustainable alternatives for producing natural products, reducing reliance on overharvested sources and enabling scalability.

Despite these opportunities, significant challenges remain. Sustainable sourcing and biodiversity preservation are critical concerns, particularly as many bioactive compounds originate from rare or slow-growing organisms. Furthermore, the structural complexity of natural products often complicates large-scale synthesis and production. Overcoming these obstacles will require a multifaceted approach, including ethical bioprospecting practices, equitable benefit-sharing mechanisms, and the development of green extraction technologies to minimize environmental impact while maximizing societal benefits. To alleviate the pressure on natural ecosystems, researchers are increasingly leveraging synthetic biology and in vitro cultivation techniques. By engineering microbial systems and cultivating rare plants in controlled environments, scientists can sustainably produce valuable natural compounds. Additionally, integrating traditional knowledge with modern scientific methodologies continues to present promising pathways for discovery and innovation.

Among the natural product sources, plants remain the most extensively explored, due to their extraordinary diversity of secondary metabolites, which serve as therapeutic agents, agrochemicals, and cosmetic ingredients. Their continued prominence underscores their critical role in providing solutions for global needs, alongside emerging contributions

from microorganisms and marine organisms. Looking ahead, the ethical and sustainable development of these resources will be paramount to ensuring their benefits for future generations.

As we conclude this Special Issue, it is evident that natural product research is advancing rapidly. The innovative studies presented here highlight transformative developments, from optimizing extraction techniques to uncovering novel bioactivities. These contributions underscore the importance of interdisciplinary approaches in unlocking the full potential of natural products. Collectively, they provide a robust foundation for addressing global challenges while inspiring future research directions.

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