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Editorial

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Recent Advances in Plant-Derived Anti-Cancer Compounds: Promising Leads

Cancer remains a substantial global health burden, and despite breakthroughs in traditional therapies such as chemotherapy, radiation, and surgery, serious difficulties such as toxicity, drug resistance, and limited selectivity persist. In this regard, plant-derived substances (phytochemicals) are increasingly being investigated as potential sources of safer and more effective cancer treatments. Recent research from 2024 and 2025 shows that nature still has a lot to give in the fight against cancer, revealing new molecular leads and mechanistic insights.

A notable review published in RSC Advances in early 2025 gives a comprehensive evaluation of plant secondary metabolites, such as alkaloids, terpenoids, flavonoids, and polyphenols, that have demonstrated anti-cancer efficacy in a variety of cancer types. The authors point out that some of these chemicals, such as berberine, curcumin, quercetin, resveratrol, and sulforaphane, are already in various phases of clinical studies, indicating a high translational potential. They also describe several modes of action, such as inducing apoptosis, modulating the PI3K/Akt, STAT-3, and Ras/MAPK signaling pathways, and inhibiting cell proliferation (Kangra et al., 2025). On the molecular-targeting front, a recent *in silico* study published in Scientific Reports (2025) discovered numerous phytochemicals with promising binding affinity to EGFR (Epidermal Growth Factor Receptor), a critical driver in many malignancies (Dipa et al., 2025). Other investigations also indicated that numerous phytochemicals, including magnolin, gracillin, hirsutine, morroniside, arctiin, and fraxin, exhibited intriguing anticancer potential (Bhuia et al., 2023a, 2023b, 2023c, 2024; Chowdhury et al., 2024; Ferdous et al., 2024). This suggests that specialized plant-derived compounds could be created or refined to suppress EGFR-mediated tumor growth, providing a more tailored therapy strategy, among other possibilities.

Another cutting-edge computational study, employing multi-ligand simultaneous docking (MLSD), assessed substances from *Withania somnifera* (withaferin A) and *Garcinia indica* (garcinol). The results revealed a synergistic effect: when docked together, these drugs demonstrated higher inhibition of BCL-2 and AKT 1, both important proteins that help cancer cells avoid apoptosis (Biswas et al., 2025). Similarly, *Moringa oleifera* phytochemicals (such as apigenin, hesperetin, and niazimicin A) showed very high binding affinity to BCL-2 in a recent MLSD investigation, outperforming several commercial inhibitors (Saha et al., 2024). These computational findings are quite interesting and could inform future drug discovery efforts. Beyond their direct anti-tumor actions, phytochemicals' immunomodulatory potential is becoming more widely recognized. According to a 2025 review in Scholars Academic Journal of Biosciences, flavonoids, alkaloids, terpenoids, and polyphenols can dramatically modify immune responses by activating immune cells, modulating cytokine production, and altering the tumor microenvironment (Akhtar et al., 2025). They are especially attractive in the development of adjunct treatments, possibly in combination with current immunotherapies, due to their dual action, cytotoxic and immunological boosting.

In terms of specific cancer types, a 2025 Onco article offers molecular and antioxidative insights into breast cancer treatment with plant-derived chemicals (Shukla et al., 2025). The review investigates how some phytochemicals counteract oxidative stress in breast cancer cells, modulate signaling pathways, and may lessen adverse effects associated with standard treatments. Furthermore, the diversity of medicinal plants across geographies is leading to discoveries. A 2025 study in Bioengineering focuses on the growing number of plant-derived biopharmaceuticals being researched for cancer (Hashim et al., 2024). The authors underline that combining traditional ethnobotanical expertise with current drug discovery technologies can speed up the discovery of novel anti-cancer drugs.

However, despite these promising developments, fundamental problems must be addressed. Poor bioavailability, solubility difficulties, fast metabolism, and low selectivity remain significant challenges. Indeed, a 2024 review in RSC Advances found that many natural chemicals have poor transport and target specificity, limiting their therapeutic utility (Hadkar et al., 2024). Standardization of extracts and strict quality control are also required to provide consistent pharmacological effects.

Moving forward, multidisciplinary efforts are required to convert these promising phytochemicals into clinically viable treatments. This involves enhanced formulation tactics (e.g., nano-delivery systems), further *in vivo* and clinical trials, and a more in-depth investigation of compound synergies (as proposed by MLSD research). Regulatory frameworks must also change to allow and support the development of plant-based cancer therapies.

In summary, the 2024-2025 study validates the notion that plant-derived chemicals are a rich and mostly untapped source of anti-cancer medicines. Scientific advances, such as computational modeling, high-throughput screening, and immunological studies, are hastening the discovery and optimization of these drugs. If carefully created and rigorously tested, phytochemicals could form the foundation of the next generation of safer, more effective cancer medicines.

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