2026 Volume: 02 Issue: 05 www.ijrpa.com ISSN 2456-9995 Review Article

International Journal Research Publication Analysis

Page: 01-04

RECENT ADVANCES IN CANCER PHARMACOLOGY: TARGETED THERAPY, PHYTOCHEMICALS, AND NANOCARRIER-BASED DRUG DELIVERY SYSTEMS.

[*]Patel Mushahid Munir, Dr. Sunil. G. Shingade, Rohan Savardekar, Md. Usaiyeddudin Shaikh

India.

Article Received: 09 April 2026
Article Revised: 29 April 2026
Published on: 19 May 2026

***Corresponding Author: Patel Mushahid Munir**
India.

DOI: https://doi-doi.org/101555/ijrpa.6535

ABSTRACT

Cancer remains one of the leading causes of mortality worldwide, necessitating the development of novel therapeutic approaches beyond conventional chemotherapy and radiotherapy. Recent advances in targeted therapy, phytochemical research, and nanocarrier-based drug delivery systems have revolutionized cancer pharmacology. Targeted therapies specifically inhibit molecular pathways critical for tumor growth and survival, thereby minimizing systemic toxicity. Phytochemicals derived from medicinal plants offer multi-targeted anticancer mechanisms with fewer adverse effects. Meanwhile, nanocarrier systems enhance drug bioavailability, target specificity, and reduce off-target toxicity. This review summarizes recent advances, mechanisms of action, and pharmacological insights into these three key areas shaping the future of cancer treatment.

KEYWORDS: Cancer pharmacology, targeted therapy, phytochemicals, nanocarriers, drug delivery, oncology.

1. INTRODUCTION

Cancer is characterized by uncontrolled cellular proliferation, invasion, and metastasis due to genetic and epigenetic alterations [1]. Despite progress in conventional chemotherapy, resistance, toxicity, and poor selectivity limit therapeutic outcomes [2]. The evolution of targeted therapy, phytochemical-based interventions, and nanotechnology-based delivery systems represents a paradigm shift in oncology [3]. These modern pharmacological strategies aim to achieve precision, safety, and efficacy in cancer management.

2. Targeted Therapy in Cancer Pharmacology

2.1 Concept and Mechanism

Targeted therapy involves the inhibition of specific molecular targets essential for cancer cell proliferation or survival. These include growth factor receptors, tyrosine kinases, and signaling molecules such as EGFR, VEGF, HER2, and BCR-ABL [4]. Unlike traditional chemotherapy, targeted agents act selectively, sparing normal cells [5].

2.2 Major Classes of Targeted Therapies

1. Monoclonal antibodies (mAbs): e.g., Trastuzumab (HER2 inhibitor) and Bevacizumab (VEGF inhibitor) [6].
2. Tyrosine kinase inhibitors (TKIs): e.g., Imatinib, Erlotinib, Sorafenib targeting intracellular kinases [7].
3. Immune checkpoint inhibitors: Targeting CTLA-4, PD-1, or PD-L1 to enhance immune- mediated cancer cell death [8].

2.3 Pharmacological Challenges

Despite success, targeted therapies face resistance due to mutations, pathway redundancy, and tumor heterogeneity [9]. Combination therapy and personalized medicine are emerging strategies to overcome these limitations.

3. Phytochemicals as Potential Anticancer Agents

3.1 Overview

Phytochemicals, bioactive compounds derived from plants, possess anticancer properties through modulation of cellular signaling pathways, apoptosis induction, and antioxidant activity [10].

3.2 Mechanisms of Action

1. Apoptosis induction: Compounds such as curcumin, resveratrol, and quercetin activate caspase- dependent pathways [11].
2. Inhibition of angiogenesis: Epigallocatechin gallate (EGCG) from green tea inhibits VEGF signaling [12].
3. Cell cycle arrest: Genistein and berberine modulate cyclins and CDKs [13].
4. Epigenetic modulation: Certain polyphenols alter DNA methylation and histone acetylation patterns [14].

3.3 Pharmacological Significance

Phytochemicals act via multi-targeted mechanisms, which reduce the risk of resistance development [15]. However, their poor solubility, bioavailability, and pharmacokinetics limit linical use, motivating the use of nanotechnology-based formulations [16].

4. Nanocarrier-Based Drug Delivery in Oncology:

4.1 Role of Nanotechnology in Cancer Pharmacology

Nanocarriers such as liposomes, polymeric nanoparticles, dendrimers, and micelles provide improved drug delivery by enhancing permeability, retention, and targeted delivery to tumor tissues [17].

4.2 Advantages of Nanocarriers

Improved bioavailability and stability of anticancer drugs.

Passive and active targeting using ligands such as folate or antibodies [18]. Reduced systemic toxicity by controlled drug release [19].

4.3 Examples of Approved Nano formulations:

1. Doxil® (liposomal doxorubicin) for ovarian cancer.
2. Abraxane® (albumin-bound paclitaxel) for breast cancer.
3. Onivyde® (liposomal irinotecan) for pancreatic cancer [20].

4.4 Future Prospects:

Combination of phytochemicals encapsulated in nanocarriers and targeted therapy approaches represents a synergistic strategy in precision oncology [21].

5. CONCLUSION

The integration of targeted therapy, phytochemical research, and nanocarrier technology has significantly advanced the field of cancer pharmacology. Future research should emphasize personalized treatment, molecular diagnostics, and combination therapy to maximize efficacy and minimize toxicity. The convergence of these three strategies offers a promising framework for next-generation anticancer therapeutics.

6. REFERENCES

1. Hanahan D, Weinberg RA. Hallmarks of Cancer: The Next Generation. Cell. 2011;144(5):646– 674.
2. Longley DB, Johnston PG. Molecular mechanisms of drug resistance. J Pathol. 2005;205(2):275–292.

3. Garraway LA, Lander ES. Lessons from the cancer genome. Cell. 2013;153(1):17–37.
4. Zhang J et al. Targeted cancer therapies: progress and perspectives. Cancer Lett. 2019; 458:1–
5. Vanneman M, Dranoff G. Combining immunotherapy and targeted therapies in cancer treatment. Nat Rev Cancer. 2012;12(4):237–251.
6. Carter PJ, Lazar GA. Next generation antibody drugs: pursuit of the 'high-hanging fruit'. Nat Rev Drug Discov. 2018;17(3):197–223.
7. Roskoski R. Small molecule inhibitors in cancer therapy. Pharmacol Res. 2019; 144:19–50.
8. Pardoll DM. The blockade of immune checkpoints in cancer immunotherapy. Nat Rev Cancer. 2012;12(4):252–264.
9. Holohan C et al. Cancer drug resistance: an evolving paradigm. Nat Rev Cancer. 2013;13(10):714–726.
10. Cragg GM, Newman DJ. Natural products: a continuing source of novel drug leads. Biochim Biophys Acta. 2013;1830(6):3670–3695.
11. Aggarwal BB, Harikumar KB. Potential therapeutic effects of curcumin, the anti-inflammatory agent, against neurodegenerative, cardiovascular, pulmonary, metabolic, autoimmune, and neoplastic diseases. Int J Biochem Cell Biol. 2009;41(1):40–59.
12. Shankar S et al. EGCG inhibits growth of human pancreatic tumors in mice. Cancer Res. 2008;68(11):4338–4346.
13. Sarkar FH, Li Y. Mechanisms of cancer chemoprevention by soy isoflavone genistein. Cancer Metastasis Rev. 2002;21(3-4):265–280.
14. Link A et al. Epigenetic mechanisms in chemoprevention of cancer by dietary polyphenols. Mutat Res. 2010;693(1-2):84–93.
15. Kotecha R et al. Phytochemicals in cancer treatment: from preclinical to clinical trial. Front Pharmacol. 2016; 7:281.
16. Iqbal J et al. Nanotechnology-based drug delivery of natural products for cancer therapy. Curr Pharm Des. 2018;24(42):4879–4898.
17. Shi J et al. Cancer nanomedicine: progress, challenges and opportunities. Nat Rev Cancer. 2017;17(1):20–37.
18. Bertrand N et al. Cancer nanotechnology: the impact of passive and active targeting in the era of modern cancer biology. Adv Drug Deliv Rev. 2014; 66:2–25.
19. Wicki A et al. Nanomedicine in cancer therapy: challenges, opportunities, and clinical applications. J Control Release. 2015;200:138–157.
20. Barenholz Y. Doxil®—the first FDA-approved nano-drug: lessons learned. J Control Release. 2012;160(2):117–134.
21. Prasad R et al. Nanotechnology in sustainable agriculture: recent developments, challenges, and perspectives. Front Microbiol. 2017;8:1014