Asian J Biol Life Sci., 2026; 15(3):633-640.
https://ajbls.com

Review Article

The Role of Medicinal Plant in Breast Cancer Management: A Comprehensive Review

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ABSTRACT

Breast Cancer is the most prevalent cancer among women across the globe that has experienced conventional interventions that encompass chemotherapy and radiations that have not been effective in a significant measure because of the acquisition of resistance, serious side effects and treatment problems. In that respect research has resorted to what is observed in the alternative and complementary medicine arena, namely the role of medicinal plants as a potential remedy. *Withania somnifera, Curcuma longa, Hydrastis canadensis, Salvia miltiorrhiza, Nigella sativa* plants have already been reported to contain phytochemicals that do function as anti-cancer which act through various of the weak points of the cancer cells such as promoting apoptosis and cell death, inhibition of tumor growth and even regulating the estrogen receptors. This review is compiled in order to give the current day picture regarding the use of medicinal plants in the treatment of breast cancer and how they work as well as their active constituents and their eradication and treatment value. This article also deliberate on the problems under consideration with the use of these plants in a clinical context such as standardization of products, right dosages and also problems of interaction with conventional care. This also critically examine the information that possess substantiates the role of said plants in breast cancer and project forward that they do exist as an addition to traditional treatment which could subsequently open up new challenges in the prepping and treatment of this most grave illness.

Keywords: Blood Vessel Growth, Breast Cancer, Complementary and Alternative Medicine, Estrogen Receptors, Herbal Remedies, Phytochemistry, Programmed Cell Death.

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Received: 15-07-2026;
Revised: 06-08-2026;
Accepted: 28-09-2026.

INTRODUCTION

Breast cancer continues to be the most common cancer affecting women globally, contributing substantially to illness and death (Tunçel, 2025). Although conventional treatments such as chemotherapy, surgery, radiotherapy, and targeted therapies have improved, issues related to drug resistance, severe side effects, and treatment-related toxicity remain. These difficulties have led to increased research into complementary and alternative medicine, specifically medicinal plants, as potential therapeutic options (Siddiqui *et al*., 2025). Phytochemicals from medicinal plants have shown notable anticancer effects through various mechanisms and offer a potentially beneficial approach for both preventing and treating breast cancer (Wu *et al*., 2025).

OPEN ACCESS

Manuscript TECHNOMEDIA

DOI: 10.5530/ajbls.20260013

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Mechanisms of Action of Medicinal Plants in Breast Cancer

Apoptosis and Cell Death Pathway Induction

Inducement of programmed cell death in breast cancer cells is one of the most important mechanisms through which medicinal herbs are known to have anticancer effects. Various phytochemicals kill cancer cells by causing intrinsic and extrinsic apoptotic pathways (Banna *et al*., 2024). Much has been known about how Withaferin A, a *Withania somnifera* steroidal lactone, can prevent the proliferation of breast cancer cells by destabilizing the microtubules and specifically addressing β -tubulin (Antony *et al*., 2014).

Curcumin, the active constituent of *Curcuma longa*, is also another famous example of apoptosis caused by phytochemicals (San and Ngai., 2025). This polyphenolic molecule raises the cytotoxic capacity of conventional chemotherapeutic drugs by modifying some signalling pathways and promoting caspase-dependent and caspase-independent apoptotic processes. Likewise, when used in combination with cisplatin, the anticancer effect of berberine, an alkaloid of plants such as *Hydrastis canadensis*, is synergistic,

leading to DNA breaks and caspase-3-dependent apoptosis (Figures 1 and 2) (Zhao *et al.*, 2016).

Modification of Important Signalling Routes

Medicinal herbs regulate many of the key cancer-related signalling pathways, such as the NF- kB and PI3K/Akt, MAPK pathways and the Wnt/β-catenin pathways. In *Scutellaria baicalensis*, there is a flavonoid named baicalein that suppresses the Epithelial-Mesenchymal Transition (EMT) by suppressing the Wnt/ -catenin pathway and SATB1 (Ma *et al.*, 2016). Such two-fold inhibition is able to prevent the process of cancer cells migration in addition to invasion, which are both essential processes required to disseminate metastases.

PKM2/ -catenin axis is another gene target of therapeutic plant chemicals. The cryptotanshinone in *Salvia miltiorrhiza* has the ability to inhibit glycolysis and reduce cell migration in breast cancer by inhibiting this pathway (Zhou *et al.*, 2020). Cryptotanshinone is strategically used in eliminating chemotherapy-resistant and chemotherapy-sensitive breast cancer cells through breaking down metabolic restructuring and downregulating 2-catenin signalling (Table 1) (Dalil *et al.*, 2022).

Immunomodulatory Impacts

Medicinal plants enhance anti-tumor immunity in many different ways as well as the direct cytotoxic effects. Certain phytochemicals inhibit the proliferation of T-cells, tumour antigen presentation as they activate the action of macrophages and dendritic cells (Baraya *et al.*, 2017). Thymoquinone of *Nigella sativa* has the immunomodulatory potential by promoting the cytotoxic response of the natural killer cells with regard to breast cancer (Alshaibi *et al.*, 2022). The use of Thymoquinone enhances the secretion of granzyme B, interferon-gamma, and perforin, which increase the ability of immune cells to eliminate cancer cells.

Besides, medicinal plant extracts change the tumour microenvironment by reducing the infiltration of myeloid-derived suppressor cells and promoting the shift of the immune phenotype toward anti-Tumor (M1) rather than pro-Tumor (M2) macrophages (He *et al.*, 2022). Due to their immunomodulatory effects, medicinal plants can be particularly beneficial when immunotherapy methods are combined with them, which can enhance the efficacy of checkpoint inhibitors (Zheng *et al.*, 2023).

Certain Medicinal Plants with Proven Anti-Breast Cancer Properties

Traditional Asian Plants and Ocimum sanctum

Ocimum sanctum or clove basil has exhibited significant antiproliferative and pro-apoptotic effects on MCF-7 breast cancer cells through mitochondrial pathway and gene regulation, which have seen it emerge as a future candidate in the treatment of breast cancer. Of particular interest is the effectiveness of the plant in treating triple-negative breast cancer or the unusual type of cancer that manifests aggressiveness and low chances of treatment.

Phaenera variegata is rich in flavonoids and other bioactive compounds, showing an anti-cancer effect with diverse mechanism of action, which include induction of apoptosis, inhibition of tumour growth and antioxidant properties. Their multicomponent composition contributes to their therapeutic versatility since a number of ingredients of these extracts of plants may affect various biological processes at the same time (Alsubhi, 2023).

East Asian and African Medicinal Plants

Through extensive research on medicinal plants in different geographical locations many species that have significant anti-breast cancer potential have been discovered. *Cymbopogon citratus* (lemongrass), *Withania somnifera* (ashwagandha), *Curcuma longa* (turmeric), *Camellia sinensis* (tea) and *Moringa oleifera* (drumstick tree) among others have in East Africa demonstrated potential in tempering the aggressiveness of breast cancer and also preventing the proliferation of cancer bearing cells (Alum *et al.*, 2024). These botanicals lower the population of cancerous stem cells and change cancer-associated pathways to offer their anticancer impacts.

Nigerian medicinal plants, like *Vernonia amygdalina*, exhibit anticancer activity through the caspase-dependent pathway and also the p53-independent pathway (Wong *et al.*, 2013). The growth of the breast cancer cells in both MCF-7 and MDA-MB-231 cell lines is inhibited by the methanolic extract of *V. amygdalina* which induces apoptosis via both intrinsic and extrinsic pathway. Together with standard chemotherapy agents such as doxorubicin, this plant forms a striking synergistic action effect and improves treatment outcome with a significant probability of reducing the required doses.

Particular Substances and Formulations

Various medicinal plants have been studied with regard to some bioactive chemicals that have anti-cancer effects. Anti-metastatic efficacy of fruit extract of *Ricinus communis* L. is strong and it prevents proliferation of breast cancer cells by preventing their migration and invasion (Majumder *et al.*, 2019). The extract has also been shown to work on both estrogen-positive MCF-7 and aggressive triple-negative MDA-MB-231 breast cancer cells due to its mechanism containing the reduction of anti-apoptotic Bcl-2 and overexpression of pro-apoptotic Bax proteins.

Moringa oleifera leaves processed into n-hexane fractions induce T47D breast cancer cell apoptosis and cell cycle arrest through the down-regulation of the anti-apoptotic protein Bcl-2 and cell cycle regulator protein cyclin D1 (Gaffar *et al.*, 2019). Artonin E, a prenylated flavonoid compound in *Artocarpus elasticus*, presents certain cytotoxicity against triple-negative breast cancer through

the activation of intrinsic and extrinsic apoptotic cascades (Etti *et al.*, 2017).

Methods of Synergistic Combination

Combining Conventional Chemotherapy with Medicinal Plants

One of the best potential applications of medicinal herbs in the treatment of breast cancer is combination therapy with traditional chemotherapeutic medicines. Combining curcumin with chemotherapeutic drugs may possess a remarkable synergistic effect, which significantly enhances anticancer effects whilst reducing the quantity of drugs required and reducing the frequency of side effects. Based on the results of meta-analysis, the overall survival and time to progression rates of patients who underwent additional complementary Chinese Herbal Medicine (CHM) therapy alongside conventional chemotherapy were better along with increased tumour response rates, in comparison to control groups that did not receive any extra intervention (Ho *et al.*, 2021).

Withania somnifera (Ashwagandha) and intermittent fasting inhibits cisplatin resistance by synergizing their induction of apoptosis and inhibition of cell growth in breast cancer (Jawarneh and Talib 2022). *In vivo* studies revealed that this combination approach reduced tumour size as well as enhanced the level of cure as compared to cisplatin-sensitive as well as cisplatin-resistant breast cancer cell lines.

Hesperidin and chlorogenic acid have a synergistic effect on reducing the proliferation of breast cancer cells through a mechanism that involves modulating the oestrogen receptor and mitochondrial pathway, which is better, compared with economic maximization when used independently (Hsu *et al.*, 2021). These polyphenolic chemicals induce apoptosis by regulating mitochondrial biogenesis genes and inhibiting the production of ATP through different pathways than through the use of conventional chemotherapy.

Regimens for Triple Combinations

Three phytochemical compounds are used concurrently in advanced combination techniques. When combined, piperine from black pepper, sulforaphane from cruciferous vegetables, and thymoquinone from *Nigella sativa* demonstrate increased anticancer activity (Aumeeruddy and Mahomoodally 2019). This triple combination reduces chemotherapy-associated toxicity, modifies cell signalling pathways, and increases chemotherapy efficacy by inhibiting multidrug resistance transporters, among other complementary mechanisms.

Table 1: Phytochemicals as Adjuvants to Conventional Cancer Therapies: Mechanisms of Action and Supporting Evidence.

Phytochemical	Conventional Therapy	Mechanism	References
Resveratrol	Doxorubicin	Significantly improved the cellular accumulation of Dox by downregulating the expression levels of ATP-binding cassette (ABC) transporter genes, MDR1, and MRP1	(Kim *et al.*, 2014)
Curcumin	Chemotherapy	Modulates NF-κB and MAPK pathways, enhancing apoptosis and reducing chemotherapy side effects	(Tan and Norhaizan, 2019)
Quercetin	Docetaxel	Induction of apoptosis and modulation of PI3K/AKT, MAPK/ERK, and JAK/STAT3 signaling pathways	(Safi *et al.*, 2021)
Berberine	Cisplatin	Suppresses breast cancer cell growth through induction of DNA breaks and caspase-3-dependent apoptosis	(Zhao *et al.*, 2016)
Sulforaphane	Paclitaxel	Enhances apoptosis by modulating the Nrf2 and NF-κB pathways, improving paclitaxel's efficacy	(Burnett *et al.*, 2017)
Lycopene	Tamoxifen	Reduces oxidative stress and counteracts hormone-related complications during tamoxifen therapy	(Zboril *et al.*, 2023)
Astaxanthin	Radiotherapy	Reduces oxidative stress and inflammation, protecting healthy tissues during radiotherapy	(McCall *et al.*, 2018)
Pomegranate extract	Tangeretin	Increases p53 and Bax expression	(Gul *et al.*, 2021)
Beta-carotene	Lupeol	Reduces oxidative stress and inflammation	(Jana *et al.*, 2023)
Cannabidiol	Photodynamic therapy	Induces cell death via apoptosis	(Mokoena *et al.*, 2024)

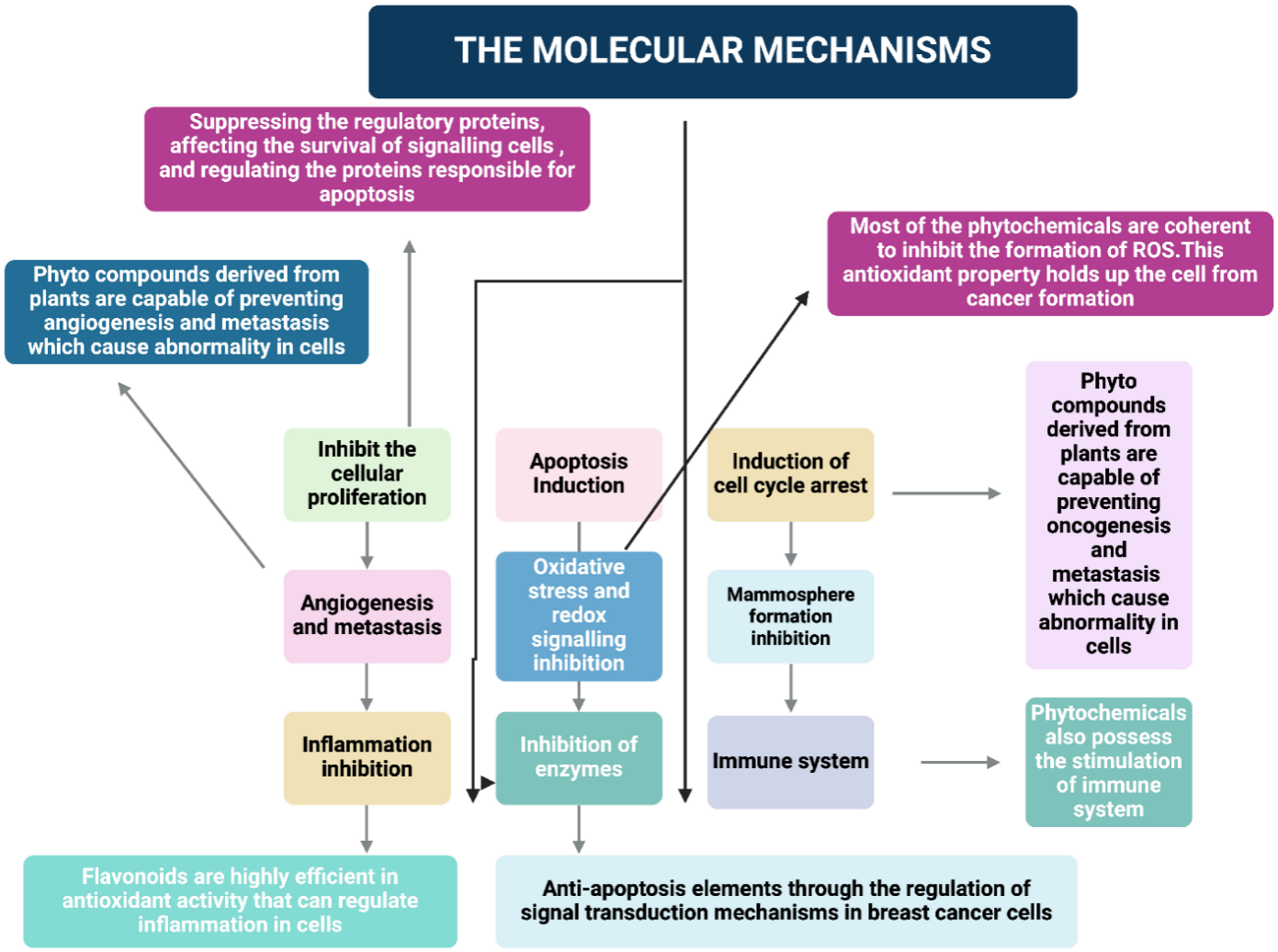


Figure 1: Phytochemicals molecular processes in cancer therapy. It illustrates their functions in cell cycle, apoptosis, and cellular proliferation. Phytochemicals control redox signalling and inhibit angiogenesis, metastasis, oxidative stress, and inflammation. Enzymes are inhibited, mammosphere development is modulated, and immune system activity is increased, Because flavonoids are antioxidants, their anti-apoptotic regulation, targeting of breast cancer cells, and prevention of the rate of perfusion appear promising.

When taken with chemotherapy for breast cancer, modified *Xiaoyao San*, a traditional Chinese herbal remedy, shows improved efficacy (Pan *et al.*, 2023). When compared to chemotherapy alone, combination therapy dramatically increased objective remission rates, quality of life, and leukocyte recovery while lowering nausea, vomiting, and cardiotoxicity, according to a meta-analysis of 17 randomised controlled trials with 1207 patients.

Focusing on Triple-Negative Breast Cancer

Research on medicinal plants should focus on triple-negative breast cancer because it is a particularly aggressive subtype with few treatment options. Through the suppression of the SIRT6/NF-κB pathway, natural substances such as icariin, a flavanol glycoside from medicinal plants, specifically prevent TNBC proliferation and induce apoptosis. In TNBC animal models, icariin significantly inhibited tumour growth and decreased pulmonary metastasis; transcriptome studies confirmed that it effectively suppressed the NF-κB pathway (Song *et al.*, 2020).

Through the downregulation of RB, RAS, PI3K, and AKT signaling pathways, *Drynaria fortunei*, a nutritious herb from traditional Chinese medicine, shows growth inhibitory activity in TNBC cellular models (Telang *et al.*, 2024). The herb provides molecular evidence for its usage in TNBC prevention and therapy by inducing S phase arrest while upregulating caspase 3/7 activity.

Overcoming Resistance to Drugs

In the fight against multidrug resistance, a significant obstacle in the treatment of breast cancer, medicinal herbs provide clear benefits. By suppressing P-glycoprotein expression and encouraging proteasome-mediated survivin degradation, Schisandrin B, a dibenzocyclooctadiene derivative from *Schisandrae Chinensis* Fructus, dramatically increases doxorubicin sensitivity in drug-resistant breast cancer. Both efflux-based and

apoptosis-evasion mechanisms of drug resistance are successfully eliminated by this dual mechanism (Wang *et al.*, 2017).

Compared to chemotherapy alone, Compound Kushen Injection, which is made from *Sophora flavescens* and *Smilax glabra*, is more effective at enhancing tumour response and lowering side effects (Lai *et al.*, 2022). CKI plus chemotherapy significantly improved objective response rates, disease control rates, and Karnofsky Performance Scale scores while lowering adverse events like leukopenia and thrombocytopenia, according to a meta-analysis of 30 randomised controlled trials involving 2556 patients.

Clinical Support and Meta-Analytical Results

Quality of Evidence and Clinical Results

Clinical effects are demonstrated by extensive meta-analyses of Chinese herbal therapy in the treatment of breast cancer. Patients receiving supplemental CHM therapy had considerably greater tumour response rates (52% with CHM versus 38% with conventional therapy alone under RECIST 1.1 criteria), according to an analysis of 81 randomised controlled studies with 7215 people. Additionally, compared to conventional therapy, CHM therapy was linked to a mean time to progression that was 2.79 months longer and an overall survival that was 1.90 months longer.

A meta-analysis of 22 randomised controlled trials involving traditional Chinese medicine and chemotherapy for patients with postoperative breast cancer showed that combined therapy significantly increased therapeutic effectiveness rates, improved immune function markers (CD3, CD4, CD4/CD8), and decreased adverse reactions related to chemotherapy, such as thrombocytopenia and leukopenia (Zhang and Shi, 2024).

Quality of Life and Symptom Management

Medicinal herbs have been shown to be effective in controlling treatment-related adverse effects and enhancing quality of life in addition to their direct anti-tumor actions. One of the most prevalent and crippling side effects of cancer treatment is cancer-related fatigue, which Chinese herbal medicine successfully treats (Yang *et al.*, 2023). A TCM herbal decoction called modified Xiang Bei Yang Rong Tang helped cancer survivors with their emotional exhaustion and cognitive performance (Chan *et al.*, 2025).

By regulating luteinizing hormone and follicle-stimulating hormone, traditional Chinese medicine lessens perimenopausal

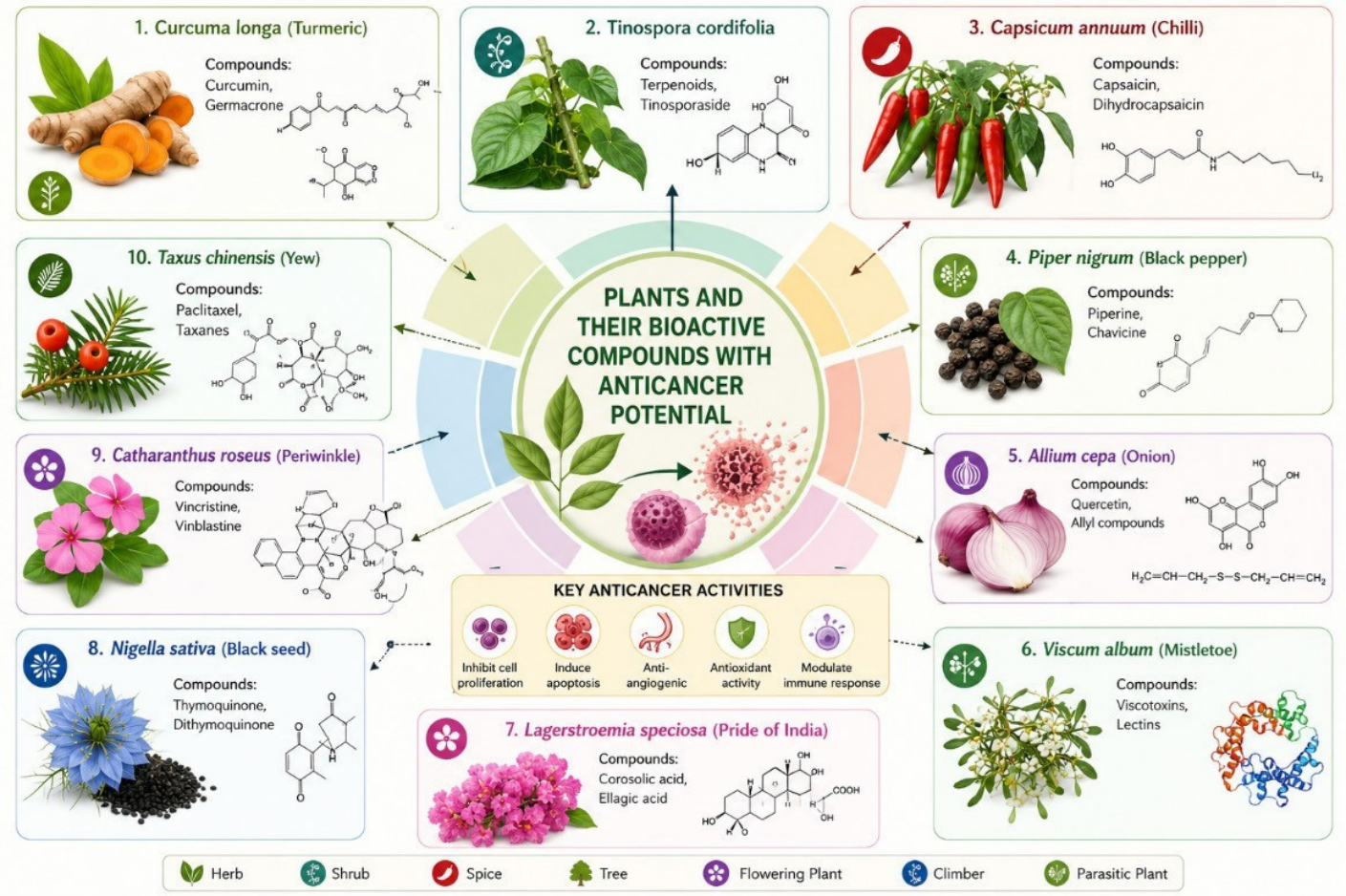


Figure 2: Certain bioactive chemicals found in medicinal plants may have anticancer effects.

symptoms associated with chemotherapy without adversely affecting endocrine therapy (Wang *et al.*, 2024). TCM significantly reduced Kupperman Menopausal Index scores and improved anxiety, sleeplessness, and osteoarthralgia symptoms, according to a meta-analysis of 42 randomised controlled studies including 3112 breast cancer patients.

Nano-Formulations and Advanced Delivery Systems

Delivery Using Nanoparticles

The therapeutic potential of medicinal plant chemicals has been improved by recent developments in nanotechnology. When compared to free apigenin, apigenin-loaded poly(lactide-co-glycolide) nanoparticles with folate targeting exhibited 3.77 times more cytotoxicity against MCF-7 breast cancer cells (Patra *et al.*, 2024). Targeted delivery can significantly improve treatment outcomes, as seen by the Nano-formulation's IC_{50} values of 13.3μM compared to 50.2μM for the free medication.

Chemotherapy medications with curcumin-loaded polymeric nanoparticles exhibit improved synergistic effects and decreased systemic toxicity. By facilitating targeted distribution to tumour locations and increasing therapeutic absorption, these Nano-formulations may lower necessary dosages and side effects.

Multimodal Combination Treatments

Multimodal therapeutic approaches are made possible by the integration of medicinal plants with cutting-edge technologies. In preclinical models, photothermal therapy combined with chemotherapy utilizing chemicals derived from medicinal plants resulted in 89.3% tumour inhibition rates (Lin *et al.*, 2024). To produce better therapeutic results, these hybrid techniques combine physical modalities with the special qualities of phytochemicals.

Obstacles and Prospects

Translating medicinal plant research into clinical practice still faces a number of obstacles, despite encouraging preclinical and early clinical findings. Clinical evidence quality is still inconsistent, with many trials exhibiting low to moderate methodological quality. Because bioactive constituent profiles differ greatly depending on plant origin, growing conditions, and extraction techniques, it is still difficult to standardize herbal extracts and identify active compounds (Shrihastini *et al.*, 2021).

The medicinal potential of many phytochemicals is limited by their bioavailability. However, the pharmacokinetic characteristics of medicinal plant components are still being improved by the use of bioenhancers like piperine, the creation of semi-synthetic derivatives, and the advancement of Nano-formulation technologies. To conclusively determine the clinical efficacy and safety of medicinal plants in the treatment of breast cancer, future research should prioritize robust randomized controlled trials with sufficient sample sizes, standardized outcome measures, and long-term follow-up assessments (Asma *et al.*, 2022).

CONCLUSION

Medicinal herbs are a rich source of bioactive chemicals that have been shown to have anti-breast cancer efficacy through a variety of pathways, such as immunomodulation, cell cycle arrest, apoptosis induction, and metastasis suppression. The extensive body of research shows that certain phytochemicals can improve the effectiveness of traditional chemotherapy while lowering treatment-related side effects, which is especially advantageous for patients with aggressive subtypes like triple-negative breast cancer. To completely determine the role of medicinal plants in evidence-based breast cancer care, more research through rigorous randomised controlled trials is still necessary, even as clinical evidence continues to mount, especially through meta-analyses of Chinese herbal medicine. Medicinal plants are positioned as viable adjuvant or alternative therapy alternatives for the management of breast cancer due to the integration of traditional knowledge with contemporary scientific methodologies, as well as advancements in delivery technology and combination strategies.

ABBREVIATIONS

ABC: ATP-binding cassette; **AKT:** Protein kinase B; **ATP:** Adenosine triphosphate; **Bax:** Bcl-2-associated X protein; **Dox:** Doxorubicin; **ERK:** Extracellular signal-regulated kinase; **JAK**: Janus kinase; **MAPK:** Mitogen-activated protein kinase; **MDR1:** Multidrug resistance protein 1; **MRP1:** Multidrug resistance-associated protein 1; **NF-κB:** Nuclear factor kappa-light-chain-enhancer of activated B cells; **Nrf2:** Nuclear factor erythroid 2-related factor 2; **p53:** Tumor protein p53; **PI3K:** Phosphoinositide 3-kinase; **STAT3:** Signal transducer and activator of transcription 3.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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Cite this article: Joshi P, Mansoor S, Mishra M. The Role of Medicinal Plant in Breast Cancer Management: A Comprehensive Review. Asian J Biol Life Sci. 2026;15(3):633-40.