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Exploring the potential of Himalayan medicinal plants in breast cancer treatment: Traditional knowledge, current limitations, and future directions

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Globally, breast cancer poses a persistent and serious health issue, with its incidence steadily increasing. Traditional medicinal plants from the Indian Himalayas offer promising potential for treatment. Our review evaluates traditional knowledge and practices in the Himalayan region concerning the use of medicinal plants for breast cancer treatment. It identified 31 plants with potential for managing breast cancer, belonging to 30 genera and 24 families. The Asteraceae and Fabaceae families were the most represented, each contributing three species, followed by Amaryllidaceae and Zingiberaceae. Regarding plant habits, herbs were the most frequently utilized, followed by trees, climbers, and shrubs. Various plant parts, were used in treating breast cancer with fresh or dried leaves being most common, followed by roots and bark. Numerous bioactive substances with anticancer qualities, including flavonoids, alkaloids, terpenoids, tannins, saponins, steroids, and glycosides, are found in these anticancer plants. They have a range of inhibitory actions against cancer cells through apoptosis, microtubule and cytokine inhibition, inhibition of transcription factor NF-κB, and Histone Acetyltransferases (HATs). Himalayan medicinal plants hold potential as anticancer agents against breast cancer; However, most studies lack scientific validation and rely on anecdotal evidence. Further research is required to establish their mechanisms and therapeutic relevance.

Keywords: Antiproliferative, Breast cancer, Herbal medicine, Indian Himalaya

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Introduction

Cancer, characterized by abnormal cell proliferation, asexual reproduction, and invasive traits altering surrounding tissue, remains a leading cause of mortality worldwide[1]. It is identified as a leading or contributing cause of death before the age of 70 in 112 out of 183 countries, affecting millions globally[2]. Among cancers, breast cancer stands out as a significant cause of death among women, categorized as adenocarcinoma[3]. The South-East Asia region is projected to see a substantial 61.7% rise in breast cancer fatalities by 2040[4]. Historically, the first recorded case of breast cancer dates back to ancient Egypt in 1500 BC, where treatments were limited to palliative care. The treatment and results for breast cancer frequently rely on several factors, including the cancer stage, the initial tumour size, the involvement of axillary lymph nodes, and the presence of distant metastasis[5].Treating breast cancer typically involves chemotherapy and radiation, which are not only costly but also cause serious side effects that impact patients' quality of life[6]. In light of the ongoing challenge to find effective anticancer treatments that minimize harm to healthy tissues, researchers have increasingly turned to traditional medicinal plants, particularly those from regions like the Indian Himalayas, to explore their potential in combating breast cancer[7]. Ethno-pharmaceutical plants have significantly contributed to discovering new drugs across various diseases, including cancer[8]. Therefore, identifying and understanding the mechanisms of traditionally effective anticancer plants could pave the way for developing innovative cancer therapies. We have undertaken this review to compile existing literature on the therapeutic potential of medicinal plants in the treatment of breast cancer. Fig. 1 provides an overview of medicinal plants with documented anticancer activity in breast cancer, summarizing their potential therapeutic roles.

Sources and Methodology

In order to retrieve the most relevant literature, an extensive search was performed across electronic databases including Google Scholar, PubMed, Scopus, SciFinder, ScienceDirect, SpringerLink, Wiley Online

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Library, and Web of Science. Search terms included "Traditional plants for breast cancer," "Medicinal plants," "Anticancer herbs," "Anticancerous plants of the Himalayas," "Mechanism of action," and "Anticancer activity." Collected data is arranged in tables for each medicinal plant and each bioactive component, after which they were highlighted and discussed.

A total of 110 articles were initially retrieved, of which 32 were identified as duplicates and non-relevant and subsequently removed, leaving 78 articles for screening. 68 articles were included as they addressed the study question. Among them, 55 were research papers, 10 were review papers, 1 was a book, 1 was a book chapter, and 1 was a conference article. A total of 28 articles provided data specifically related to plant species used in breast cancer management. Of these, 12 articles contained only ethnomedicinal information (6 research articles, 5 reviews, and 1 book chapter). The remaining 16 articles included traditional medicinal data and laboratory experiments on the selected plants.

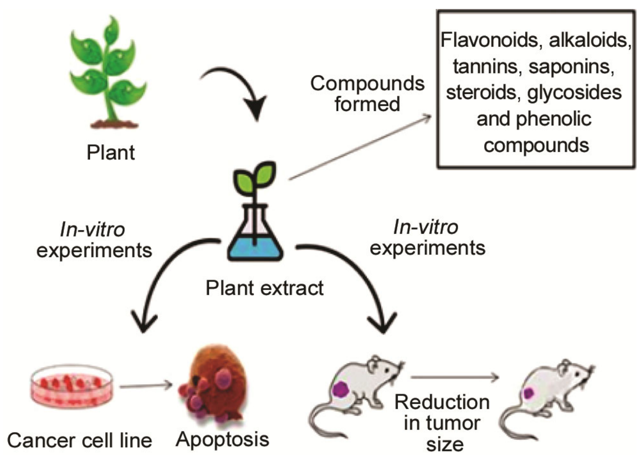

Fig. 1 — Medicinal plants and their anticancer effects in breast cancer.

Additionally, 40 articles were selected to gather data on *in vitro* experiments related to these plants, while only 6 articles included data on *in vivo* experiments. The search was primarily restricted to articles available in English and published between 2015 and 2025; however, 21 articles published between 2003 and 2015 were also included as they addressed key research questions. Articles were included based on the following selection criteria: Reported plants and their parts traditionally used for breast cancer treatment, along with phytochemical extracts and findings from *in vitro* and *in vivo* experiments performed on these plants (Table 1).

Results and Discussion

The literature review focused on the Himalayan region of India, identified 31 plant species, from 30 genera and 24 families, with potential anti-breast cancer activity. Among these, Asteraceae and Fabaceae were the most dominant families, each represented by three species. These families have demonstrated notable efficacy in breast cancer treatment, attributed to their unique bioactive compounds, including sesquiterpenes and bioflavonoids, which possess strong anticancer properties[41]. The frequent use of Asteraceae and Fabaceae in cancer treatment is partly due to their large number of species, increasing the likelihood of their

Table 1 — Traditionally used medicinal plants in the Himalayas for the treatment of breast cancer

S. No.	Scientific Name	Local Name	Family	Habit	Parts Used	Reference
1	*Aegle marmelos* (L.) Corrêa	Bael	Rutaceae	Tree	Fruit pulp, Bark	9,10
2	*Albizia lebbeck* (L.) Benth.	Siris tree	Fabaceae	Tree	Bark	11
3	*Allium sativum* L.	Garlic	Amaryllidaceae	Herb	Leaves	12,13
4	*Allium wallichii* Kunth	Ban Lasun	Amaryllidaceae	Herb	Whole plant	14,15
5	*Amomum subulatum* Roxb.	Elaichi	Zingiberaceae	Herb	Seeds	16
6	*Annona squamosa* L.	Seetapalam	Annonaceae	Tree	Aerial part	11
7	*Arnebia euchroma* I.M.Johnst.	Ratanjot	Boraginaceae	Herb	Whole plant	17,18
8	*Asparagus racemosus* Willd.	Wild Shatavari, Ekalkanto	Liliaceae	Herb	Roots	19,20
9	*Azadirachta indica* A.Juss.	Dhrek	Meliaceae	Tree	Leaves	21
10	*Bauhinia variegata* L.	Koiralo	Fabaceae	Tree	Bark	22
11	*Berberis aristata* DC.	Kashmal, Chutro	Berberidaceae	Shrub	Stem	23
12	*Bidenspilosa* L.	Kateeli	Asteraceae	Herb	Leaves	11
13	*Butea monosperma* (Lam.) Kuntze	Taub, Pala	Fabaceae	Tree	Flowers	24
14	*Cannabis sativa* L.	Bhang	Cannabaceae	Herb	Seeds	11
15	*Catharanthus roseus* (L.) G.Don	Nayantara, Sada sawagan	Apocynaceae	Herb	Root	11,25

(*Contd.*)

Table 1 — Traditionally used medicinal plants in the Himalayas for the treatment of breast cancer

S. No.	Scientific Name	Local Name	Family	Habit	Parts Used	Reference
16	*Curcuma longa* L.	Haldi	Zingiberaceae	Herb	Whole plant	26
17	*Cyanthillium cinereum* (L.) H.Rob.	Mookkuthi, Poondu	Asteraceae	Herb	Whole plant	11,27
18	*Digitalis purpurea* L.	Fox glove	Plantaginaceae	Herb	Leaves	28
19	*Dioscorea bulbifera* L.	Gittha	Dioscoreaceae	Climber	Rhizome, root	29
20	*Eupatorium cannabinum* L.	Banmara	Asteraceae	Herb	Aerial parts	30
21	*Moringa oleifera* Lam.	Sajina	Moringaceae	Herb	Seeds	15,31
22	*Phyllanthus embellica* L. sohlhu	Aamla, avla	Phyllanthaceae	Tree	Fruits	32
23	*Podophyllum hexandrum* Royle	Bankankari	Berberidaceae	Herb	Leaves	33
24	*Potentilla fulgens* Wall. Ex Hook.	Bajradanti	Rosaceae	Herb	Root	34
25	*Punica granatum* L.	Darim	Lythraceae	Tree	Fruits peels	35
26	*Rubia cordifolia* L.	Majito	Rubiaceae	Climber	Roots and aerial part	36
27	*Semecarpus anacardium* L. F.	Ballataka	Anacardiaceae	Tree	Nuts	37
28	*Smilax zeylanica* L.	Kukur	Smilaxcaceae	Climber	Stems	38
29	*Solanum nigrum* L.	Kalobehi	Solanaceae	Herb	Fruits	39
30	*Taxus wallichiana* Zucc.	Lauthsalla, barmi, banya	Taxaceae	Tree	Leaf and bark	11
31	*Terminalia chebula* Retz.	Harra	Combretaceae	Tree	Fruits	40

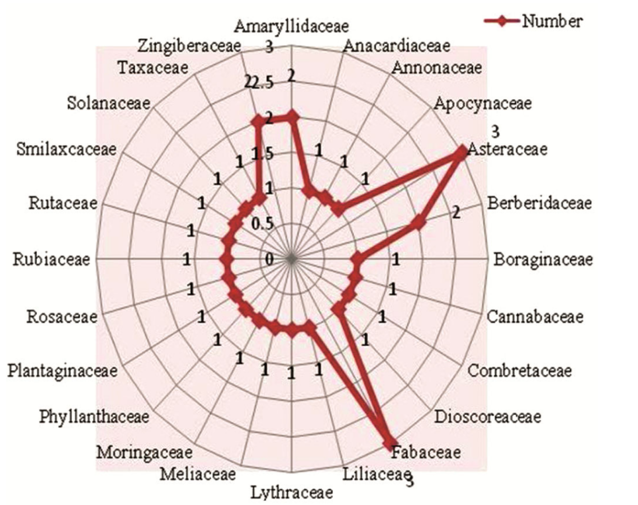

Fig. 2 — The total number of anticancerous plant species under each taxonomic family.

application[42]. However, some members of other plant families also play a significant role in cancer treatment, including Amaryllidaceae and Zingiberaceae (2 species each), along with Anacardiaceae, Annonaceae, Apocynaceae, Berberidaceae, Boraginaceae, Cannabaceae, Combretaceae, Dioscoreaceae, Liliaceae, Lythraceae, Meliaceae, Moringaceae, Phyllanthaceae, Plantaginaceae, Rosaceae, Rubiaceae, Rutaceae, Smilacaceae, Solanaceae, and Taxaceae (1 species each) (Fig. 2).

Herbs and Leaves: Key resources for breast cancer cure

Herbs (16 species) are the most frequently utilized plants for treating breast cancer, followed by trees (11 species), climbers (3), and shrubs (1).Their rich concentration of natural compounds and medicinal properties makes herbs popular in alternative and complementary cancer therapies[43].

Among the various plant parts used, fresh or dried leaves are the most frequently utilized, followed by roots, bark, whole plant, fruits, stem, nuts, flowers, rhizome, and peels. Leaves, in particular, have shown notable potential in suppressing the growth of breast cancer cells and minimizing tumour size. Their rich content of bioactive compounds, such as polyphenols and flavonoids, contributes to strong anticancer properties and may be crucial in preventing the development and progression of breast cancer[44].

Scientific evidence highlights the potential of leaves in regulating cancer cell activity, making them a promising resource for developing new therapeutic approaches[45]. Additionally, due to their abundance and ease of collection, leaves offer a more sustainable alternative to root harvesting, that often involves destructive uprooting and may threaten the survival of rare or slow-growing medicinal plants[46].

An important observation from the review is the limited use of scientifically validated diagnostic methods in traditional breast cancer management studies. Most articles do not provide detailed information on how the disease is diagnosed by practitioners, with many relying on subjective symptoms such as chronic breast pain, palpable lumps, and loss of appetite. This suggests a gap in integrating modern diagnostic tools with traditional practices.

Experimental assessment of anticancer activity in medicinal plants

Traditional medicinal plants have been extensively studied for their anticancer properties through both *in vitro* and *in vivo* experiments. Among the *in vitro* techniques, the MTT assay (3-[4,5-dimethylthiazol-2-yl]-2,5-diphenyltetrazolium bromide) remains the most frequently employed method to assess the cytotoxic effects of plant extracts on various breast cancer cell lines. This assay measures cell viability by detecting the metabolic activity of living cells, providing insights into the potential of plant extracts to inhibit cancer cell growth. For *in vivo* testing, experiments have been conducted on various animal species, with mice being the predominant and nearly exclusive choice. Researchers have employed this approach to assess the efficacy of plant-derived compounds in targeting breast cancer cells, advancing the development of alternative cancer therapies.

Major anticancer compounds obtained from medicinal plants

Number of bioactive compounds are isolated from plant part/s like polyphenols (Tannin, catechin, epicatechin curcumin, ellagic acid, ellagitannins, gallic acid) flavonoids (Anthocyanins and anthocyanidins); steroidal sapogenin (Diosgenin, smilagenin); alkaloids (Vinblastine, vincristine epipodophyllotoxinlignans, taxanediterpenoids); pentacyclic triterpenoid (Euscaphic acid, ursolic acid); triterpenoid (Corosolic acid); organosulphur (Allicin); Phytosterol (β-Sitosterol); aryltetralin-type lignans (4′-demethyl-podophyllotoxin-4-O-β-d-glucopyranoside); conjugated linolenic acid (punicic acid); Cannabinoids; hydroxybenzaldehyde; saponin; steroid; glycosides; fulgic acid A and B etc were found to be very effective in controlling cancer experimentally. The most commonly used compounds formed in most plants are flavonoids, alkaloids, terpenoids, tannins, saponins, steroids, glycosides, and phenolic compounds. Such compounds significantly contribute in inhibiting cancer cells through DNA mutilation and stimulate apoptosis-inducing enzymes[47]. Flavonoids have shown notable effectiveness against breast cancer, with research on animal models and cell cultures suggesting that their tumour-inhibiting potential largely stems from their antioxidant, free radical-scavenging abilities[48].

***In vitro* evaluation of anticancer effects of medicinal plant extracts**

Evaluating various plant extracts for their anticancer activity has yielded significant findings, emphasizing the efficacy of these natural compounds in targeting breast cancer cell lines. For instance, Seemaisamy *et al*. demonstrated that methanol and acetone extracts derived from the leaves of *Aegle marmelos* effectively reduced the proliferation of MDA-MB-231 breast cancer cells, achieving IC_{50} values of 61.79 µg/mL and 79.62 µg/mL, respectively[49]. This corroborates the findings of Aditya *et al.*, who reported that a methanol extract of *Albizzia lebbeck* leaves, obtained through Soxhlet extraction, exhibited anticancer activity against MCF-7 cells, with nearly 50% inhibition at a concentration of 200 µg/mL[50]. The similarities in these findings suggest a promising avenue for further exploration of methanol-based extracts in anticancer therapies. In a related study, Velsankar *et al*. found that an aqueous extract from *Allium sativum* leaves, when combined with silver nanoparticles, demonstrated efficacy against MCF-7 cells, resulting in an IC_{50} value of 89.86 µg/mL[51]. This enhancement of anticancer activity through nanoparticle encapsulation highlights the effectiveness of novel delivery systems in enhancing the bioavailability and effectiveness of plant extracts.

Bhandari *et al*. also reported that a crude extract from the bulbs of *Allium wallichii* exhibited moderate cytotoxicity towards MCF-7 cells, achieving a 45.22% inhibition at 50 µg/mL[14]. Studies using multiple *Allium* species suggest a broader potential for this genus in cancer treatment strategies. Further supporting the therapeutic efficacy of phytochemicals against cancer, Al-Ghazzawi identified two alkaloids from *Annona squamosa* that showed remarkable effects on MCF-7 cells, showing IC_{50} values of 15.345 and 1.358 µg/mL[52]. These findings indicate that specific compounds may offer stronger inhibitory effects compared to crude extracts, a notion supported by Tariq *et al*., who found that acetylshikoninfrom *Arnebia euchroma* inhibited MCF-7 cell growth with an impressive IC_{50} of 3.04 µg/mL[6]. Such results emphasize the importance of isolating and characterizing individual phytochemicals to uncover their therapeutic potential. Moreover, Dhanusha *et al*. reported that methanolic extracts from *Asparagus racemosus* inhibited MCF-7 cells, yielding an IC_{50} value of 91.36±0.87 µg/mL[20]. This adds to the growing body of evidence that methanolic extracts are effective against breast cancer cells, further supported by Chaudhary & Goyal, who highlighted that neem leaf methanolic extracts exhibit significant cytotoxic effects on MCF-7 breast cancer cells, that inhibited its growth by up to 40-80% at 25-100 µg/mL[53]. The consistent efficacy of these extracts underscores the relevance of plant-based therapies in combating breast cancer.

Mishra *et al.* contributed in a similar line by showing that a benzene extract from *Bauhinia variegata* inhibited MCF-7 cells by up to 70% at 100 µg/mL[54]. This finding, along with Lamichhane *et al.* (IC_{50} of 33.31 µg/mL for a methanol extract from *Berberis aristata*), illustrates the diverse range of plants that possess anticancer properties[55]. These studies support the use of phytochemicals as promising leads in breast cancer drug discovery, highlighting the need for ongoing research into their pharmacological potential. Kviecinskia *et al.* found that a hydro-ethanol extract from the aerial parts of *Bidens pilosa* demonstrated inhibitory effects on the MCF-7 cell line, with an IC_{50} of 437 µg/mL[56]. This highlights the potential of *Bidens pilosa* as a candidate for further research into breast cancer therapies. In a related study, Kaur *et al*. evaluated chloroform and ethyl acetate extracts from the bark of *Butea monosperma*. Their findings indicated that these extracts exhibited antiproliferative and apoptotic activities in MCF-7 cells, with IC_{50} values of 203.7 µg/mL and 246.5 µg/mL, respectively[57].

These results are significant as they suggest that both extracts may contribute to breast cancer treatment strategies, particularly in targeting cell proliferation and inducing apoptosis. Further adding to the diversity of plant-based anticancer agents, Bala *et al*. reported that dichloromethane (DCM) extracts from *Cannabis sativa* flowers, leaves, and stems inhibited MCF-7 cells with IC_{50} values ranging from 65-100 µg/mL, utilizing cytotoxicity and Vascular Endothelial Growth Factor (VEGF) inhibition assays[58]. This underscores the potential of *C. sativa* in breast cancer therapeutics, especially given its comparatively lower IC_{50} values, indicating higher potency. In another interesting study, Widowati *et al*. used flow cytometry to evaluate the antiproliferative activity of ethanol extracts derived from the roots and aerial parts of *Catharanthus roseus*, observing a percentage inhibition of 37.48% at a concentration of 50 µg/mL[25]. This demonstrates the promising anticancer activity of *C. roseus*, suggesting its utility in therapeutic applications (Table 2).

Evidence from *in vivo* experiments

The exploration of the anticancer properties of medicinal plants through *in vivo* experiments has

Table 2 — Experimental *in vitro* studies of the antitumor activities of Himalayan medicinal plants

Name of plant	Part used	Concentration (µg/mL)	Inhibition (%)	Extract	Anticancer compound	Method	Reference
Aegle marmelos (L.) Corrêa	Bark, fruit, pulp extract, seeds	61.79 and 79.62	50%	Methanol and acetone	Alkaloids, flavonoids, tannins, and saponins	MTT	49
Albizia lebbeck (L.) Benth.	Leaves	200	50%	Methanol	Saponin	MTT	50
Allium sativum L.	Leaves	89.86	50%	Aqueous extracts	Allicin, flavonoids, and phenolic components	MTT	51
Allium wallichii Kunth	Bulb extract	50	45.22%	NA	Flavonoids, steroids, glycosides, and terpenoids	MTT	14
Annona squamosa L.	Aerial part	15.345 and 1.358	50%	Aqueous extracts	Alkaloids (6, 7-dimethoxy-1-(α-hydroxy-4-methoxybenzyl)-2-methyl-1, 2, 3, 4-tetrahydroisoquinolin and Coclaurine	Sulforhodamine B assay (SRB)	52
Arnebia euchroma I.M.Johnst.	Roots	3.04	50%	Ethyl-acetate extract	Nephthoquinine (phenolic)	MTT	6
Asparagus racemosus Willd.	Tuber	91.36+ 0.87	50%	Methanolic	Steroids, alkaloids, flavonoids, glycosides, saponins, and diterpenes	MTT	20
Azadirachta indica A. Juss.	Leaves	25-100	40-80%	Ethanolic and Methanolic	Nimbolide, Quercetin, Gedunin	MTT	53
Bauhinia variegata L.	Stem	100	75%	Benzene	Terpenoid, alkaloid, tannin	SRB	54
Berberis aristata DC.	Stem	33.31	50%	Methanol extraction	Alkaloid (berberine), steroids, flavonoids, coumarin, and terpenoids	MTT	55
Bidens pilosa L.	Aerial part	437	50%	Supercritical fluid extract, hydro-ethanol maceration	Polyacetylenes	MTT	56
Butea monosperma (Lam.) Kuntze	Bark	203.7 and 246.5	50%	Chloroform and ethyl acetate	Catechin, epicatechin, and gallic acid	MTT	57

(*Contd.*)

Table 2 — Experimental *in vitro* studies of the antitumor activities of Himalayan medicinal plants

Name of plant	Part used	Concentration (µg/mL)	Inhibition (%)	Extract	Anticancer compound	Method	Reference
Cannabis sativa L.	Flowers, leaves, and stems	65-100	50%	N-hexane, Dichloromethane (DCM)	Cannabinoids	Cytotoxicity and VEGF inhibition assay	58
Catharanthus roseus (L.) G.Don	Aerial part and root	50	37.48%	Ethanol	Alkaloids, vinblastine, and vincristine	Flow cytometry	25,59, 60
Curcuma longa L.	Rhizome	1-30	50-90%	Ethanolic extract	Curcumin	MTT	61
Cyanthillium cinereum (L.) H.Rob.	Entire plant	12.5-10.4	50%	Crude extract	Sesquiterpene lactone	MTT	62
Digitalis purpurea L.	Seeds	8.3 -20	50%	Chloroform extract	Pregnane, steroidal, and cardenolide glycosides	Flow cytometry	63
Dioscorea bulbifera L.	Leaves	115.63±86.01	50%	Chloroform extract	Alkaloid and terpenoid	MTT	29,64
Eupatorium cannabinum L.	Aerial parts	100	80%	Methanol extract	Eucannabinolide	MTT	30
Moringa oleifera Lam.	Seeds	400	50%	Hexane extract	NA	Antiproliferative assay	31
Phyllanthus embellica L.sohlhu	Fruit extract	50-200	60-80%	Methanolic and aqueous extract	Polyphenols (Gallic acid, ellagic acid), emblicanin A & B	Methyltetrazolium Salt Assay (MTS)	65
Podophyllum hexandrum Royle	Roots	0.5-5	50%	Ethyl-acetate and n-butanol extract	4′-demethyl-podophyllotoxin-4-O-β-d-glucopyranoside	NA	66,67
Potentilla fulgens Wall. Ex Hook.	Root	45 to 75	50%	Ethyl-acetate and hexane extract	Fulgic acid A and B, ursolic acid, euscaphic acid, corosolic acid, epicatechin, catechin, *p*-hydroxybenzaldehyde, and gallic acid	High-Performance Liquid Chromatography (HPLC)	31
Punica granatum L.	Fruit	49.08	50%	Methanol extract	Ellagic acid, punicic acid, ellagitannins, anthocyanins and anthocyanidins, flavones, flavonoids, and estrogenic flavonols	MTT	68,69
Rubia cordifolia L.	Roots	8-50	50%	Ethanol	Anthraquinones (purpurin, alizarin), cyclic hexapeptides (RA-I to RA-XXIV), mollugin	MTT	70
Semecarpus anacardium L. F.	Leaf, nuts, and seed oil	0.57	50%	Ethyl-acetate extract	Alkaloids, carbohydrates, glycosides, phenolic compounds, Saponins, steroids, terpenoids, tannins, flavonoids	MTT	37,71,72
Smilax zeylanica L.	Roots	15.49±1.18	50%	Petroleum ether	Diosgenin, smilagenin, and β-sitosterol	NA	38,73
Solanum nigrum L.	Fruit	5	78.3%	Ethanol extract	NA	MTT	74
Taxus wallichiana Zucc.	Stem bark	20	50%	NA	2-deacetoxytaxinine J (2-DAT-J)	MTT	75
Terminalia chebula Retz.	Fruit	100	80%	Methanolic extract	Chebulinic acid, Gallic acid	MTT	40

revealed valuable insights into their potential therapeutic applications. While some plants have been extensively studied, others still require further investigation. Most *in vivo* studies have predominantly utilized mice as the experimental model, which provides a consistent platform for assessing the efficacy of various extracts and compounds. For instance, research on *Aegle marmelos* demonstrated its *in vivo* anticancer potential against DMBA-induced mammary carcinoma in rat models. The ethanolic extract of the fruit pulp was orally administered at a dosage of 200 mg/kg body weight over a period of five weeks, leading to a significant reduction in tumour volume and normalization of key biomarkers such as TNF-α, malondialdehyde (MDA) and glucose levels. The treatment also improved liver and kidney function parameters without any observed toxicity. This finding highlights the medicinal efficacy of *A. marmelos* fruit pulp in breast cancer management through its antioxidative and anti-inflammatory properties[9]. In another noteworthy study, Othman *et al.* evaluated the anticancer potential of Neem leaf extract in female BALB/c mice, administering it at doses of 250 and 500 mg/kg, and the incidence of apoptosis in breast cancer tissues was assessed using the TUNEL assay[76]. The results indicated that both treatment groups had a significantly higher apoptosis rate than the cancer control group, highlighting Neem's potential in inducing cell death in cancerous tissues. The chemopreventive properties of *Butea monosperma* were evaluated in Sprague-Dawley rats, where mammary cancer was induced using Methylnitrosourea (MNU). Administration of methanolic flower extract of *B. monosperma* resulted in a 33.33% reduction in tumour incidence at the highest dose (400 mg/kg).

Additionally, significant reductions in tumour weight and volume were observed across all treatment groups, confirming methyl extract of *Butea monosperma's* antiproliferative effects[24]. Similarly, *Curcuma longa* (turmeric) has been extensively studied for its anticancer efficacy. In an *in vivo* experiment carried out by Ferreira *et al.*, human breast cancer was developed in athymic mice, followed by intraperitoneal treatment with curcumin at a daily dose of 300 mg/kg. The treatment resulted in a marked decrease in tumour size and cellular proliferation relative to the control group, affirming the potential of curcumin as a potent anticancer agent[77]. Additionally, Yousefirad *et al*. examined the impact of *Moringa oleifera* extract on tumour-induced BALB/c mice. Daily administration of varying doses (0.02, 0.04, and 0.08 g) for four weeks showed a remarkable reductions in tumour size, with the 0.02 g dose exhibiting the highest efficacy in promoting apoptosis and reducing tumour volume (P<0.001)[78]. These evidences collectively highlight the promising anticancer potential of a variety of medicinal plants through *in vivo* experimentation.

These results lay the foundation for future investigations and open avenues for developing natural therapeutic agents for cancer treatment. However, further research is required to clarify the molecular mechanisms involved and fully assess the therapeutic potential of these extracts.

Conclusion

Our review highlights 31 therapeutic plant species of the Indian Himalayan region traditionally used for breast cancer treatment, with species from the Asteraceae and Fabaceae families being most prominent. Herbaceous plants were most commonly utilized, reflecting their accessibility and cultural familiarity. In addition to traditional claims, supporting *in vitro* and *in vivo* studies have also been presented, indicating the strong therapeutic potential of these plants against breast cancer. However, a critical gap remains in the diagnostic practices of traditional healers, as treatments are often administered without clinical confirmation of the disease. Therefore, caution is essential when using herbal remedies, as improper dosages or unverified treatments can result in a delay in conventional treatment for breast cancer or adverse health effects. Therefore, while traditional knowledge and phytomedicine offer exciting possibilities, they must be complemented by evidence-based practices and professional guidance to ensure safety and efficacy. Bridging this gap through scientific validation and collaboration with local knowledge holders could greatly enhance the credibility and effectiveness of plant-based therapies.

Conflicts of interest

The authors affirm that no conflicts of interest exist regarding this study.

References

1 Smeltzer S C, Bare B G, Hinkle J L and Cheever K H, *Brunner and Suddarth's Textbook of Medical Surgical Nursing*, 12th ed (Wolters Kluwer London, England), 2010.

2 Sung H, Ferlay J, Siegel R L, Laversanne M, Soerjomataram I, *et al.*, Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries, *CA: Cancer J Clin*, 2021, **71**(3), 209-249.

3 McGrowder D A, Miller F G, Nwokocha C R, Anderson M S, Wilson-Clarke C, *et al.*, Medicinal herbs used in traditional management of breast cancer: Mechanisms of action, *Medicines*, 2020, **7**(8), 47, doi: 10.3390/ medicines7080047.

4 Sathishkumar K, Sankarapillai J, Mathew A, Nair R A, Gangane N, *et al.*, Breast cancer survival in India across 11 geographic areas under the national cancer registry programme, *Cancer*, 2024, **130**(10), 1816-1825.

5 Prat A, Pineda E, Adamo B, Galván P, Fernández A, *et al.*, Clinical implications of the intrinsic molecular subtypes of breast cancer, *The Breast*, 2015, **24**(1), 26-35.

6 Tariq A, Mussarat S and Adnan M, Review on ethnomedicinal, phytochemical and pharmacological evidence of Himalayan anticancer plants, *J Ethnopharmacol*, 2015, **164**, 96-119.

7 Jan S and Abbas N, Utilization and Botanical Significance of Himalayan Herbs. In *Himalayan phytochemicals: sustainable options for sourcing and developing bioactive compounds*, (Elsevier), 2018, 33-77.

8 Schmidt B, Ribnicky D M, Poulev A, Logendra S, Cefalu W T, *et al.*, A natural history of botanical therapeutics, *Metabolism*, 2008, **57**, S3-S9.

9 Sharma N, Radha, Kumar M, Zhang B, Kumari N, *et al.*, *Aegle marmelos* (L.) Correa: An underutilized fruit with high nutraceutical values: A review, *Int J Mol Sci*, 2022, **23**(18), 10889, doi: 10.3390/ijms231810889.

10 Vardhini S P, Sivaraj C, Arumugam P, Ranjan H, Kumaran T, *et al.*, Antioxidant, anticancer, antibacterial activities and GCMS analysis of aqueous extract of pulps of *Aegle marmelos* (L.) Correa, *J Phytopharmacol*, 2018, **7**(1), 72-78.

11 Regassa H, Sourirajan A, Kumar V, Pandey S, Kumar D, *et al.*, A review of medicinal plants of the Himalayas with anti proliferative activity for the treatment of various cancers, *Cancers*, 2022, **14**(16), 3898, doi: 10.3390/cancers14163898.

12 Khan M I, Bouyahya A, Hachlafi N E, Menyiy N E, Akram M, *et al.*, Anticancer properties of medicinal plants and their bioactive compounds against breast cancer: A review on recent investigations, *Environ Sci Pollut Res*, 2022, **29**(17), 24411-24444, doi: 10.1007/s11356-021-17795-7.

13 Sato A, Yabuki A, Sato G, Nemoto H, Ogawa Y, *et al.*, Garlic (*Allium sativum* L.) organosulfur compounds inhibit breast cancer cell proliferation by decreasing steroid sulfatase levels, *Anticancer Res*, 2025, **45**(1), 145–52.

14 Bhandari J, Muhammad B, Thapa P and Shrestha B G, Study of phytochemical, antimicrobial, antioxidant, and anticancer properties of *Allium wallichii*, *BMC Complement Altern Med*, 2017, **17**, 10, doi: 10.1186/s12906-017-1654-z.

15 Țigu A B, Moldovan C S, Toma V A, Farcaș A D, Moț A C, *et al.*, Phytochemical analysis and *in vitro* effects of *Allium fistulosum* L. and *Allium sativum* L. extracts on human normal and tumor cell lines: A comparative study, *Molecules*, 2021, **26**(3), 574.

16 Sharma V, Lohia N, Handa V and Baranwal M, *Amomum subulatum* seed extract exhibit antioxidant, cytotoxic and immune suppressive effect, *Indian J Biochem Biophys*, 2017, **54**(3-4), 135-139.

17 Dhanjal D S, Chopra C and Singh R, Himalayan Herbal Medicine for Cancer, edited by S K Singh, C Chopra and R Singh, In *Modern Cancer Therapies and Traditional Medicine: An Integrative Approach to Combat Cancers*, (Bentham Science Publishers), 2021, 268-288.

18 Devi U and Thakur M, Exploration of ethnobotanical uses of some wild plants from cold deserts of Himachal Pradesh, *Asian J Exp Biol Sci*, 2011, **2**, 312-316.

19 Mitra S K, Prakash N S and Sundaram R, Shatavarins (containing Shatavarin IV) with anticancer activity from the roots of Asparagus racemosus, *Indian J Pharmacol*, 2012, **44**(6), 732-736, doi: 10.4103/0253-7613.103273.

20 Dhanusha G, Sujith S, Nisha A R, Aathira K K and Haima J S, Cytotoxic and antiproliferative potential of methanolic extracts of *Asparagus racemosus* in MDAMB231 cells, *Pharm Innov J*, 2021, **10**(2), 355-358.

21 Kumari S, Batish D R, Singh H P, Negi K and Kohli R K, An ethnobotanical survey of medicinal plants used by Gujjar community of Trikuta Hills in Jammu and Kashmir, India, *J Med Plants Res*, 2013, **7**(28), 2111-2121.

22 Sharma N, Sharma A, Bhatia G, Landi M, Brestic M, *et al.*, Isolation of phytochemicals from *Bauhinia variegata* L. bark and their *in vitro* antioxidant and cytotoxic potential, *Antioxidants*, 2019, **8**(10), 492, doi: 10.3390/antiox8100492.

23 Nepal S, Sharma J, Bhutia S, Devi B, Yumnam S, *et al.*, Exploring anticancer properties of medicinal plants against breast cancer by downregulating human epidermal growth factor receptor 2, *J Agric Food Chem*, 2024, **72**(17), 9717-9734, doi: 10.1021/acs.jafc.4c01234.

24 Karia P, Patel K V and Rathod S S, Breast cancer amelioration by *Butea monospermain vitro* and *in vivo*, *J Ethnopharmacol*, 2018, **217**, 54-62, doi: 10.1016/j.jep.2018.02.02.

25 Widowati W, Mozef T, Risdian C, Ratnawati H, Tjahyani S, *et al.*, Apoptosis and antioxidant activities of *Catharanthus roseus* (L.) G. Don extract on breast cancer cell line, *Indones J Cancer Chemoprevent*, 2010, **1**(2), 99-107.

26 Mathur A and Joshi H, Ethnobotanical studies of the tarai region of Kumaun, Uttarakhand, India, *Ethnobot Res Appl*, 2013, **11**, 175–204.

27 Ayyanar M and Ignacimuthu S, Traditional knowledge of Kanitribals in Kouthalai of Tirunelveli hills, Tamil Nadu, India, *J Ethnopharmacol*, 2005, **102**, 246–255.

28 Lazaro M L, De La Pene N P, Pastor N, Martin C C, Navarro E, *et al.*, Anti-tumour activity of *Digitalis purpurea* L. subsp., *Heywoodii, Planta Med*, 2003, **69**(8), 701-704, doi: 10.1055/s-2003-42789.

29 Nur R M and Nugroho L H, Cytotoxic activities of fractions from *Dioscorea bulbifera* L. chloroform and methanol extracts on T47D breast cancer cells, *Pharmacogn J*, 2018, **10**(1), 33-38, doi: 10.5530/pj.2018.1.7.

30 Abuali M, Shams Ardekani M R, Rezadoost H, Vazirian M, *et al.*, Cytotoxic effects of *Eupatorium cannabinum* on MCF-7 human breast cancer cell line, *Res J Pharmacogn*, 2021, **8**(2), 69–75, doi: 10.22127/rjp.2021.263706.1654.

31 Adebayo I A, Arsad H and Samian M R, Antiproliferative effect on breast cancer (MCF-7) of *Moringa oleifera* seed extracts, *Afr J Tradit Complement Altern Med*, 2017, **14**(2), 282-287.

32 Lee S H, Jaganath I B, Wang S M and Sekaran S D, Antimetastatic effects of *Phyllanthus* on human lung (A549) and breast (MCF-7) cancer cell lines, *PLoS One*, 2011, **6**(6), e20994, doi: 10.1371/journal.pone.0020994.

33 Javaid A, Ejaz A A Z, Mubeen T N, Aamir S and Muhammad Q, Study of anticancer and antibacterial activities of *Podophyllum hexandrum* as natural curatives, *Adv Complement Altern Med*, 2020, **5**(5), 482-485.

34 Choudhary A, Mittal A K, Radhika M, Tripathy D, Chatterjee A, *et al.*, Two new stereoisomeric antioxidant triterpenes from *Potentilla fulgens*, *Fitoterapia*, 2013, **91**, 290-297.

35 Rani J and Giri S, Screening of bio-active compounds and anticancer activity of *Punica granatum* L., *World J Sci Res*, 2016, **1**(3), 6–13.

36 Mughees M, Sharma Y, Ahmad J and Ahmad A, Comparative analysis of anticancer activity of *Rubia cordifolia* L. & adulterant on MCF-7 cells and SCAR marker development, *Int J Plant Anim Environ Sci*, 2017, **7**, 70–79.

37 Jain P and Sharma H P, A potential ethnomedicinal plant *Semecarpus anacardium* Linn: a review, *Int J Res Pharm Chem*, 2013, **3**(3), 564-572.

38 Kuruppu A I, Paranagama P and Goonasekara C L, Medicinal plants commonly used against cancer in traditional medicine formulae in Sri Lanka, *Saudi Pharm J*, 2019, **27**(4), 565–73, doi: 10.1016/j.jsps.2018.12.007.

39 Son Y O, Kim J, Lim J C, Chung Y, Chung G H, *et al.*, A ripe fruit of *Solanum nigrum* L. inhibits cell growth and induces apoptosis in MCF-7 cells, *Food Chem Toxicol*, 2003, **41**(10), 1421-1428.

40 Reddy P, Pradeep S, Dharmashekar C, MR S C, Srinivasa C, *et al.*, Cell cycle arrest and apoptotic studies of *Terminalia chebula* against MCF-7 breast cancer cell line: an *in vitro* and *in silico* approach, *Front Oncol*, 2023, **13**, 1221275, doi: 10.3389/fonc.2023.1221275.

41 Li Q, Wang Z, Xie Y and Hu H, Antitumor activity and mechanism of costunolide and dehydrocostus lactone: Two natural sesquiterpene lactones from the Asteraceae family,

Biomed Pharmacother, 2020, **125**, 109955, doi: 10.1016/ j.biopha.2020.109955.

42 Aumeeruddy M Z and Mahomoodally M F, Global documentation of traditionally used medicinal plants in cancer management: A systematic review, *S Afr J Bot*, 2021, **138**, 424-94, doi: 10.1016/j.sajb.2021.03.022.

43 Khan A, Ali S, Murad W, Hayat K, Siraj S, *et al.*, Phytochemical and pharmacological uses of medicinal plants to treat cancer: a case study from Khyber Pakhtunkhwa, North Pakistan, *J Ethnopharmacol*, 2021, **281**, 114437, doi: 10.1016/j.jep.2021.114437.

44 Levitsky D O and Dembitsky V M, Anti-breast cancer agents derived from plants, *Nat Prod Bioprospect*, 2015, **5**(1), 1-16, doi: 10.1007/s13659-014-0048-9.

45 Khan T, Ali M, Khan A, Nisar P, Jan S A, *et al.*, Anticancer plants: A review of the active phytochemicals, applications in animal models, and regulatory aspects, *Biomolecules*, 2022, **10**(1), 47, doi: 10.3390/biom10010047.

46 Rao P K, Hasan S S, Bhellum B L and Manhas R K, Ethnomedicinal plants of Kathua district, J & K, India, *J Ethnopharmacol*, 2015, **171**, 12-27, doi: 10.1016/j.jep. 2015.05.031.

47 Chandra S, Gahlot M, Choudhary A N, Palai S, de Almeida R S, *et al.*, Scientific evidences of anticancer potential of medicinal plants, *Food Chem Adv*, 2023, **2**, 100239, doi: 10.1016/j.focha.2023.100239.

48 Kopustinskiene D M, Jakstas V, Savickas A and Bernatoniene J, Flavonoids as anticancer agents, *Nutrients*, 2020, **12**(2), 457, doi: 10.3390/nu12020457.

49 Seemaisamy R, Faruck L H, Gattu S, Neelamegam R, Bakshi H A, *et al.*, Antimicrobial and anticancer activity of *Aegle marmelos* and gas chromatography–mass spectrometry analysis of their chemical constituents, *Int J Pharm Sci Res*, 2019, **10**(1), 373–80, doi: 10.13040/IJPSR.0975-8232.10(1).373-80.

50 Aditya S J, Naresh K L and Mokkapati A, Evaluation of *in vitro* cytotoxicity of *Andrographis paniculata*, *Duranta serratifolia* and *Albizzia lebbeck* whole plant extracts by MTT assay against MCF-7 and HT-29 cell lines, *Curr Res Microbiol Biotechnol*, 2014, **2**, 351-353.

51 Velsankar K, Preethi R, Ram P J, Ramesh M and Sudhahar S, Evaluations of biosynthesized Ag nanoparticles via *Allium sativum* flower extract in biological applications, *Appl Nanosci*, 2020, **10**, 3675-3691, doi: 10.1007/s13204-020-01883-8.

52 Al Ghazzawi A M, Anticancer activity of new benzyl isoquinoline alkaloid from Saudi plant *Annona squamosa*, *BMC Chem*, 2016, **13**, 1-6.

53 Chaudhary A and Goyal S, Neem (*Azadirachta indica*) and its potential for breast cancer: A review, *Indian J Nat Prod Resour*, 2021, **12**(3), 325-333.

54 Mishra A, Sharma A K, Kumar S, Saxena A K and Pandey A K, *Bauhinia variegata* leaf extracts exhibit considerable antibacterial, antioxidant, and anticancer activities, *Biomed Res Int*, 2013, **2013**, 915436.

55 Lamichhane B, Adhikari S, Shrestha P and Shrestha B G, Study of phytochemical, antioxidant, antimicrobial and anticancer activity of *Berberis aristata*, *J Trop Life Sci*, 2014, **4**(1), 1-7.

56 Kviecinskia M R, Benelli P, Felipe K B, Correia J F G, Pich C T, *et al.*, SFE from *Bidens pilosa* Linné to obtain extracts rich in cytotoxic polyacetylenes with antitumor activity, *J Supercrit Fluids*, 2011, **56**, 243-248.

57 Kaur V, Kumar M, Kumar A and Kaur S, *Butea monosperma* (Lam.) Taub. bark fractions protect against free radicals and induce apoptosis in MCF-7 breast cancer cells via cell cycle arrest and ROS mediated pathway, *Drug Chem Toxicol*, 2020, **43**(4), 398-408.

58 Bala A, Mukherjee P K, Braga F C and Matsabisa M G, Comparative inhibition of MCF-7 breast cancer cell growth, invasion and angiogenesis by *Cannabis sativa* L. sourced from sixteen different geographic locations, *S Afr J Bot*, 2018, **119**, 154–162.

59 Eltayeb N M, Ng S Y, Ismail Z and Salhimi S M, Anti-invasive effect of *Catharanthus roseus* extracts on highly metastatic human breast cancer MDA-MB-231 cells, *J Teknol*, 2016, **78**(11-3), 35-40.

60 Suderan S, Paramasivam R, Sunder S, Amathy A R, Rincy R, *et al.*, Evolution of metabolic compounds of *Catharanthus roseus* and its anticancer activity, *Eur J Pharm Med Res*, 2017, **4**(9), 282-290.

61 Ahmad R, Srivastava A N and Khan M A, Evaluation of *in vitro* anticancer activity of rhizome of *Curcuma longa* against human breast cancer and vero cell lines, *Evaluation*, 2016, **1**(1), 1-6.

62 Roy J R, Julius A and Chinnapan V, Therapeutic uses and prospects of *Cyanthillium cinereum* -the underrated herb, *Biomed Pharmacol J*, 2022, **15**(3), 1335-1342.

63 Amiri F, Moghadam A, Tahmasebi A and Niazi A, Identification of key genes involved in secondary metabolite biosynthesis in *Digitalis purpurea*, *PLoS One*, 2023, **18**(3), e0277293, doi: 10.1371/journal.pone.0277293.

64 Rachaiah K, Keshavan D and Salimath B P, Antineoplastic activity of *Dioscorea bulbifera* root extracts by targeting MTA1, *Res J Life Sci Bioinformatics Pharm Chem Sci*, 2019, **5**(1), 549-563.

65 Zhao T, Sun Q, Marques M and Witcher M, Anticancer properties of *Phyllanthus emblica* (Indian gooseberry), *Oxid Med Cell Longev*, 2015, **2015**(1), 950890, doi: 10.1155/ 2015/950890.

66 Zilla M K, Nayak D, Amin H, Nalli Y, Rah B, *et al.*, 4′-Demethyldeoxypodophyllotoxin glucoside isolated from *Podophyllum hexandrum* exhibits potential anticancer activities by altering Chk2 signaling pathway in MCF-7 breast cancer cells, *Chem Biol Interact*, 2014, **224**, 100-107, doi: 10.1016/j.cbi.2014.10.003.

67 Chattopadhyay S, Bisaria V S, Panda A K and Srivastava A K, Cytotoxicity of *in vitro* produced podophyllotoxin from *Podophyllum hexandrum* on human cancer cell line, *Nat Prod Res*, 2004, **18**(1), 51-57.

68 Sreekumar S, Sithul H, Muraleedharan P, Azeez J M and Sreeharshan S, Pomegranate fruit as a rich source of biologically active compounds, *Biomed Res Int*, 2014, **2014**, 686921, doi: 10.1155/2014/686921.

69 Yi X, Liu J, Zhang Y, Wang Y, Sun L, *et al.*, Effect of punicalagin on autophagic cell death in triple negative breast cancer cells, *Arch Toxicol*, 2024, **98**(4), 421–435.

70 Wen M, Chen Q, Chen W and Yang J, A comprehensive review of *Rubia cordifolia* L.: traditional uses, phytochemistry, pharmacological activities, and clinical applications, *Front Pharmacol*, 2022, **13**, 965390, doi: 10.3389/fphar.2022.965390.

71 Singh R K, Mallik B, Ranjan A, Tripathi R, Verma S S, *et al.*, *Semecarpus anacardium* L.f. leaf extract exhibits activities against breast cancer and prolongs the

survival of tumor-bearing mice, *Nat Prod Res*, 2024, **38**(6), 1080-1084.

72 Jain P, Singh S K, Sharma H P and Basri F, Phytochemical screening and antifungal activity of *Semecarpus anacardium* L. (an anticancer plant), *Int J Pharm Sci Res*, 2014, **5**(5), 1884-1891.

73 Sethi G, Shanmugam M K, Warrier S, Merarchi M, Arfuso F, *et al.*, Pro-apoptotic and anticancer properties of diosgenin: A comprehensive and critical review, *Nutrients*, 2018, **10**(5), 645.

74 Lai Y J, Tai C J, Wang C W, Choong C Y, Lee B H, *et al.*, Anticancer activity of *Solanum nigrum* (AESN) through suppression of mitochondrial function and epithelial–mesenchymal transition in breast cancer cells, *Molecules*, 2016, **21**(5), 553, doi: 10.3390/molecules21050553.

75 Reddy K P, Bid H K, Nayak V L, Chaudhary P, Chaturvedi J P, *et al.*, *In vitro* and *in vivo* anticancer activity of 2-deacetoxytaxinine J and synthesis of novel taxoids and their *in vitro* anticancer activity, *Eur J Med Chem*, 2009, **44**(10), 3947-3953, doi: 10.1016/j.ejmech. 2009.02.022.

76 Othman F, Motalleb G, Peng S L T, Rahmat A, Fakurazi S, *et al.*, Extract of *Azadirachta indica* (Neem) leaf induces apoptosis in 4T1 breast cancer BALB/c Mice, *Cell J*, 2011, **13**(2), 107-116.

77 Ferreira L C, Arbab A S, Jardim-Perassi B V, Borin T F, Varma N R, *et al.*, Effect of curcumin on pro-angiogenic factors in the Xenograft model of Breast Cancer, *Anticancer Agents Med Chem*, 2015, **15**(10), 1285-1296, doi: 10.2174/1871520615666150520093644.

78 Yousefirad A, Rastegari A A, Shahanipour K and Monajemi R, Evaluation of proliferative inhibition effect of *Moringa oleifera* total extract on breast cancer: An *in vitro* and *in vivo* study, *Iran J Sci*, 2023, **47**, 653-662.