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Traditional Medicinal Plants: Ethnobotanical Insights in Cancer treatment

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Abstract

The use of medicinal plants has been done since ancient times and may even be considered the origin of modern medicine. Compounds of plant origin have been and still are an important source of compounds for drugs. The medicinal plants, besides having natural therapeutic values against various diseases, also provide high quality of food and raw materials for livelihood. Considerable works have been done on these plants to treat cancer, and some plant products have been marketed as anticancer drugs, based on the traditional uses and scientific reports. These plants may promote host resistance against infection by re-stabilizing body equilibrium and conditioning the body tissues. Several reports describe that the anticancer activity of medicinal plants is due to the presence of antioxidants in them. In fact, the medicinal plants are easily available, cheaper and possess no toxicity as compared to the modern (allopathic) drugs. Thus, the various combinations of the active components of these plants after isolation and identification can be made and have to be further assessed for their synergistic effects. Preparation of standardized dose and dosage regimen may play a critical role in the remedy of cancer. it has been observed that the trend in global research is focused more on the search for new medicines or active compounds rather than on the cultivation or domestication of plant species with this demonstrated potential.

Key words: *antioxidants, therapeutic, synergistic, allopathic, domestication*

Introduction:

Medicinal plants have played a pivotal role in healthcare for centuries, serving as the foundation for many modern pharmaceuticals. Nearly 60% of currently approved anticancer drugs have origins in natural products, including plant-derived compounds. Examples include vincristine and vinblastine from *Catharanthus roseus*, paclitaxel from *Taxus brevifolia*, camptothecin from *Camptotheca acuminata*, and podophyllotoxin from *Podophyllum* species. These agents have revolutionized cancer therapy, proving that nature can provide potent chemical scaffolds for drug discovery. One of the major advantages of plant-based compounds is their structural complexity, which is often difficult to replicate synthetically but allows for precise interactions with multiple cellular targets. This polypharmacology makes them effective against heterogeneous tumor cell populations and reduces the likelihood of developing resistance compared to single-target synthetic drugs.

The importance of medicinal plants in cancer therapy is further underscored by their diverse mechanisms of action. Phytochemicals such as alkaloids, flavonoids, terpenoids, saponins, and phenolic acids have been shown to modulate numerous signaling pathways involved in carcinogenesis. They can induce apoptosis, arrest the cell cycle, inhibit angiogenesis, suppress metastasis, and modulate immune responses. For example, curcumin from *Curcuma longa* has been extensively studied for its ability to regulate NF-κB, STAT3, and p53 pathways, thereby inhibiting tumor growth and promoting apoptosis. Similarly, resveratrol, a polyphenol from grapes, exhibits antioxidant, anti-inflammatory, and antiproliferative effects by modulating multiple molecular targets. These compounds often act synergistically with existing chemotherapeutic agents, enhancing their efficacy while reducing toxic side effects. This synergy is particularly important in the context of combination therapies, which are now recognized as essential for overcoming the complexity of cancer.

Medicinal plants have been a vital source of both curative and preventive medical therapy preparations for human beings, which also has been used for the extraction of important bioactive compounds [1–3]. It is estimated that almost 80% of the world's total population, regularly, depends on traditional medicine and products for its healthcare needs especially in third world countries. Many sick people in the developing regions combine the conventional medicine with traditional medicine [4–6].

Medicinal plants are used to maintain physical, mental, and spiritual health in all cultures and in a variety of capacities and contexts. Such plants include species with one or more organs that produce compounds of clinically established therapeutic value, which may be utilized directly or as precursors for drug synthesis, and others that have not been vetted as such but are believed to be therapeutically useful (e.g., as medicine, tonic, food, or cultural symbol)1–3. Iconic examples include: Papaver

somniferum L. (opium poppy), from which are derived powerful pain-relieving alkaloids like codeine and morphine; Cinchona ledgeriana Wedd. (fever bark) and Artemisia annua L. (wormwood), which yield lifesaving antimalarials; Catharanthus roseus L. (G. Don) (rosy periwinkle) and Taxus brevifolia Nutt. (Pacific yew), from which anticancer treatments like vinblastine/vincristine and paclitaxel, respectively, have been synthesized; and Dioscorea mexicana Scheidw. (Mexican yam), the source of diosgenin, a potent steroid for oral contraceptives4–6. As these remedies were discovered, humans greatly facilitated the migration of these medicinal plant species and sought to enhance their diversity. The breadth of such interactions and the numerous benefits that plants provide to humans illustrate why improved knowledge and conservation of medicinal plant species are essential,

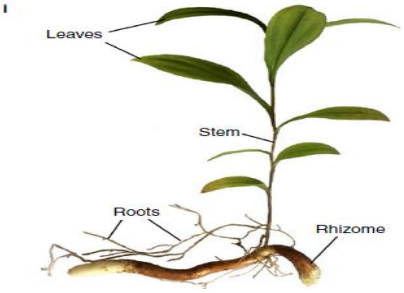

Figure-1: whole plant in which different parts of plant used for medicinal purpose

1. *Curcuma longa* (Turmeric)

Curcuma longa, commonly known as turmeric, is a perennial herb belonging to the Zingiberaceae family. Native to South Asia, it is widely used as a spice, dye, and traditional medicine. The active compound curcumin gives turmeric its bright yellow colour and is known for its potent anti-inflammatory, antioxidant, antimicrobial, and anticancer properties. It plays a significant role in Ayurveda and traditional Chinese medicine for treating various conditions, including digestive disorders, skin diseases, and joint inflammation.

(a)

(b)

Figure-2: *Curcuma longa*, commonly known as turmeric (a) standing crop (b) Stem which is used to make powder

Curcuma longa, commonly known as turmeric, is a perennial rhizomatous herb belonging to the family Zingiberaceae, widely cultivated in South and Southeast Asia. Traditionally, turmeric has been used in Ayurvedic and other indigenous medicine systems for its anti-inflammatory, antimicrobial, wound-healing, and antioxidant properties. In recent decades, turmeric has attracted significant scientific attention for its potential role in cancer prevention and therapy, largely due to its principal bioactive constituent, curcumin (diferuloylmethane), along with other curcuminoids such as demethoxycurcumin and bisdemethoxycurcumin. These compounds are polyphenolic in nature and exhibit a broad spectrum of biological activities, making turmeric a promising candidate in the field of oncology.

Curcumin exerts anticancer effects through multiple mechanisms targeting various hallmarks of cancer. One of its primary actions is the modulation of cell signaling pathways involved in proliferation, apoptosis, invasion, angiogenesis, and metastasis. Curcumin has been shown to inhibit

the activation of transcription factors such as nuclear factor-kappa B (NF-κB) and activator protein-1 (AP-1), both of which regulate genes associated with tumor progression, inflammation, and survival. It can also upregulate tumor suppressor proteins like p53 and downregulate oncogenes such as c-Myc, thereby promoting cell cycle arrest and programmed cell death in cancer cells. Furthermore, curcumin can influence multiple kinase pathways, including PI3K/Akt, MAPK, and JAK/STAT, disrupting cancer cell survival and proliferation.

Another important role of curcumin in cancer therapy is its ability to induce apoptosis through both intrinsic (mitochondrial) and extrinsic (death receptor-mediated) pathways. It promotes the release of cytochrome c from mitochondria, increases the Bax/Bcl-2 ratio, activates caspases, and triggers DNA fragmentation in cancer cells. Additionally, curcumin exhibits strong anti-angiogenic activity by inhibiting vascular endothelial growth factor (VEGF) expression and suppressing endothelial cell proliferation and migration, thereby cutting off the blood supply required for tumor growth. Its anti-metastatic effects involve inhibition of matrix metalloproteinases (MMPs), which degrade the extracellular matrix, and downregulation of adhesion molecules, limiting cancer cell invasion.

Curcumin's antioxidant properties also contribute to its anticancer potential by neutralizing reactive oxygen species (ROS) and reducing oxidative DNA damage, which is a major contributor to carcinogenesis. Moreover, curcumin's anti-inflammatory action—achieved through suppression of cyclooxygenase-2 (COX-2), lipoxygenase, and inducible nitric oxide synthase (iNOS) is particularly relevant in cancers where chronic inflammation plays a role, such as colorectal, gastric, and liver cancers. Preclinical studies have demonstrated curcumin's efficacy against a wide variety of malignancies, including breast, prostate, pancreatic, lung, and brain cancers.

In addition to its direct anticancer effects, curcumin has been reported to enhance the sensitivity of tumor cells to conventional chemotherapeutic agents such as doxorubicin, cisplatin, and 5-fluorouracil, as well as to radiation therapy. This chemosensitizing and radiosensitizing property is valuable for overcoming drug resistance and improving treatment outcomes. Importantly, curcumin exhibits low systemic toxicity in normal cells, which makes it a safer therapeutic option compared to many synthetic anticancer agents. However, a major limitation of curcumin in clinical use is its poor bioavailability due to low solubility, rapid metabolism, and systemic elimination. Various strategies, including the use of adjuvants like piperine, development of nanoparticles, liposomes, micelles, and phospholipid complexes, have been employed to improve its absorption and therapeutic efficacy.

Clinical trials evaluating curcumin in cancer patients have yielded encouraging results, particularly in reducing tumor markers, alleviating treatment-related side effects, and improving overall quality of life. For instance, studies have shown that curcumin supplementation in colorectal cancer patients

can reduce oxidative stress and inflammatory markers, while in oral cancer patients, it has been associated with regression of precancerous lesions. Despite these promising findings, larger, well-designed randomized controlled trials are needed to establish optimal dosing regimens, long-term safety, and therapeutic efficacy in diverse cancer types.

In summary, *Curcuma longa* plays a multifaceted role in cancer therapy through its primary bioactive compound, curcumin, which acts on multiple molecular targets to inhibit tumor initiation, promotion, and progression. Its combination of anti-inflammatory, antioxidant, pro-apoptotic, anti-angiogenic, and anti-metastatic properties positions it as a valuable adjunct to conventional cancer treatments. Continued research focusing on enhancing its bioavailability, elucidating synergistic interactions with existing therapies, and validating clinical efficacy will be crucial for fully realizing turmeric's potential in modern oncology.

Curcuma longa, a perennial herb from the Zingiberaceae family, is one of the most extensively studied medicinal plants for its anticancer potential. The primary bioactive constituent, **curcumin**, along with demethoxycurcumin and bisdemethoxycurcumin, is responsible for a wide range of pharmacological activities, including antioxidant, anti-inflammatory, and anticancer effects. Curcumin has been shown to modulate multiple signaling pathways implicated in carcinogenesis, such as NF-κB, STAT3, PI3K/Akt/mTOR, and MAPK. It can inhibit the proliferation of cancer cells, induce apoptosis, and suppress tumor angiogenesis by downregulating VEGF expression. Curcumin also interferes with metastasis by inhibiting matrix metalloproteinases (MMP-2, MMP-9) and epithelial-to-mesenchymal transition (EMT). Importantly, curcumin enhances the sensitivity of cancer cells to chemotherapy and radiotherapy while reducing treatment-related toxicity. It has demonstrated efficacy in preclinical and clinical studies against various cancers, including colorectal, breast, pancreatic, prostate, and lung cancers. Due to its poor bioavailability, research has focused on novel formulations like nanoparticles, liposomes, and curcumin–piperine combinations to improve therapeutic efficacy.

2. *Withania somnifera* (Ashwagandha)

Withania somnifera, also known as ashwagandha or Indian ginseng, is a revered adaptogenic herb in Ayurvedic medicine. It belongs to the Solanaceae family and is used to combat stress, fatigue, and anxiety. The roots and leaves contain withanolides, bioactive compounds known for anti-stress, anti-inflammatory, neuroprotective, and immunomodulatory effects. Ashwagandha is traditionally used to enhance strength, vitality, and longevity.

(a)

(b)

Figure-3: *Withania somnifera*, commonly known as ashwagandha or Indian ginseng (a) Seeds used to make plant extract (b) seed, flower and leaves of the plant used for medicinal purpose

Withania somnifera, commonly known as Ashwagandha or Indian ginseng, is a revered medicinal plant in Ayurveda and belongs to the family Solanaceae. Traditionally used as a rasayana (rejuvenator) for promoting vitality, longevity, and resistance to stress, Ashwagandha has been employed for centuries to treat a wide range of health conditions. In recent decades, modern research has provided scientific validation for its therapeutic benefits, particularly in oncology, where its bioactive constituents have demonstrated significant anticancer potential. The pharmacologically active compounds in *Withania somnifera* include a group of steroidal lactones known as withanolides, along with withaferin A, sitoindosides, alkaloids, and flavonoids. Among these, withaferin A has been most extensively studied for its anticancer properties.

The anticancer activity of Ashwagandha is multifaceted, targeting multiple pathways involved in tumor initiation, progression, and metastasis. Withaferin A exhibits potent pro-apoptotic effects by activating both intrinsic (mitochondrial-mediated) and extrinsic (death receptor-mediated) pathways

of cell death. It enhances the expression of pro-apoptotic proteins such as Bax and cleaved caspases, while downregulating anti-apoptotic proteins like Bcl-2, leading to mitochondrial membrane permeabilization and release of cytochrome c. This cascade results in effective elimination of cancer cells without significant damage to normal cells. In addition, withaferin A can induce cell cycle arrest at the G2/M phase, thereby inhibiting uncontrolled cell proliferation.

Another key aspect of Ashwagandha's anticancer role is its ability to modulate multiple signaling pathways implicated in oncogenesis. Withaferin A has been shown to inhibit nuclear factor-kappa B (NF-κB), a transcription factor that regulates genes involved in inflammation, cell proliferation, angiogenesis, and resistance to apoptosis. Suppression of NF-κB activity leads to reduced expression of pro-inflammatory cytokines, cyclooxygenase-2 (COX-2), and matrix metalloproteinases (MMPs), thereby limiting tumor growth, invasion, and metastasis. Additionally, *Withania somnifera* influences the PI3K/Akt/mTOR and JAK/STAT signaling pathways, which are often dysregulated in cancer, thus restoring normal cell growth and survival regulation.

Ashwagandha also demonstrates strong anti-angiogenic activity, a crucial mechanism for restricting tumor vascularization and nutrient supply. Withaferin A inhibits vascular endothelial growth factor (VEGF) expression and disrupts endothelial cell function, effectively curbing new blood vessel formation within tumors. Moreover, its antioxidant and anti-inflammatory properties protect normal tissues from oxidative DNA damage and chronic inflammation, both of which are closely linked to carcinogenesis. These protective effects make Ashwagandha not only a potential direct anticancer agent but also a supportive therapy to minimize the side effects of standard treatments.

In the context of combination therapy, *Withania somnifera* has shown chemosensitizing and radiosensitizing effects, enhancing the cytotoxicity of conventional anticancer drugs such as paclitaxel, cisplatin, and doxorubicin. This ability to sensitize cancer cells allows for lower doses of toxic chemotherapeutics, potentially reducing adverse effects. Preclinical studies have reported that withaferin A can overcome multidrug resistance (MDR) in cancer cells by modulating drug efflux pumps and altering apoptotic thresholds. Furthermore, Ashwagandha's immunomodulatory properties stimulating the proliferation and activity of natural killer (NK) cells, macrophages, and T lymphocytes the body's immune surveillance against tumor cells.

Clinical investigations on Ashwagandha have yielded promising results in improving the quality of life in cancer patients. Supplementation has been associated with reduced fatigue, better stress tolerance, improved sleep quality, and enhanced overall well-being during chemotherapy and radiotherapy. In some clinical trials, Ashwagandha extract has demonstrated potential in alleviating treatment-induced immunosuppression, thereby supporting faster recovery. Importantly, it has shown

a favorable safety profile, with minimal toxicity in both short- and long-term use when administered in appropriate doses.

In summary, *Withania somnifera* plays a significant role in cancer therapy by directly inhibiting cancer cell proliferation, inducing apoptosis, suppressing angiogenesis, and preventing metastasis, while also enhancing immune function and improving tolerance to conventional treatments. Its multitargeted action, low toxicity, and synergistic potential with standard therapies make it a valuable candidate for integrative oncology approaches. However, further well-controlled clinical trials are necessary to confirm its efficacy, determine optimal dosage regimens, and establish standardized formulations for therapeutic use in cancer patients.

Withania somnifera, commonly known as Ashwagandha or Indian Ginseng, belongs to the Solanaceae family and has been a cornerstone of Ayurvedic medicine for centuries. Its anticancer effects are mainly attributed to withanolides, steroidal lactones that modulate multiple molecular targets involved in cancer progression. Withanolides induce apoptosis through mitochondrial pathways, upregulating pro-apoptotic proteins (Bax, p53) and activating caspases. They also inhibit proliferation by causing cell cycle arrest in the G2/M phase and suppress oncogenic transcription factors such as NF-κB and STAT3.

Ashwagandha has demonstrated anti-angiogenic effects by downregulating VEGF and reducing tumor vascularization. Additionally, it modulates the immune system, enhancing natural killer (NK) cell activity and T-lymphocyte proliferation, thereby strengthening the body's natural tumor surveillance. Ashwagandha's adaptogenic properties help reduce stress hormones like cortisol, which indirectly supports immune health during cancer therapy. Preclinical studies show promising results against breast, prostate, colon, and lung cancers, and it is being explored as an adjuvant to conventional therapies due to its protective effects on normal cells during chemotherapy and radiation.

3. *Tinospora cordifolia* (Giloy)

Tinospora cordifolia, also known as Giloy or Guduchi, is a climbing shrub from the Menispermaceae family widely used in Ayurvedic medicine for its immunomodulatory, antioxidant, and anti-inflammatory properties. Its anticancer activity is attributed to alkaloids (berberine, palmatine), diterpenoid lactones, steroids, and polysaccharides. Giloy enhances host immune responses by stimulating macrophages, NK cells, and cytokine production, thereby improving the body's ability to identify and eliminate malignant cells. Its antioxidants protect cellular DNA from ROS-induced mutations, reducing cancer risk. Several studies report that Giloy extracts induce apoptosis in cancer cells through caspase activation, mitochondrial membrane depolarization, and downregulation of anti-apoptotic proteins. Additionally, Giloy inhibits tumor angiogenesis and modulates inflammatory

mediators, including COX-2 and TNF-α. Its protective effect against chemotherapy-induced myelosuppression and immunosuppression has been documented, making it a potential supportive therapy. Although most data come from in vitro and animal studies, its safety profile and multi-targeted mechanisms make it an attractive candidate for integrative cancer therapy.

Figure-4: *Tinospora cordifolia* commonly known as Giloy, Guduchi, or Amrita (climbing shrub)

Tinospora cordifolia, commonly called giloy, is a climbing shrub from the Menispermaceae family. It is highly valued in Ayurveda as a "Rasayana" herb known to enhance immunity and detoxify the body. The plant contains alkaloids, diterpenoid lactones, glycosides, and steroids that contribute to its antipyretic, antioxidant, hepatoprotective, and anti-diabetic activities. It is widely used in managing fever, diabetes, and chronic infections.

Tinospora cordifolia, commonly known as Giloy, Guduchi, or Amrita, is a climbing shrub belonging to the family Menispermaceae and is widely distributed in tropical and subtropical regions of India, Myanmar, and Sri Lanka. In Ayurvedic medicine, it is regarded as a "Rasayana" herb, meaning a rejuvenator, and has been traditionally used to enhance vitality, immunity, and resistance against diseases. Modern pharmacological studies have confirmed its wide range of bioactivities, including immunomodulatory, antioxidant, anti-inflammatory, antimicrobial, and antidiabetic effects. In oncology research, *Tinospora cordifolia* has gained attention for its potential role as a natural adjunct in cancer prevention and therapy, owing to its rich phytochemical composition that includes alkaloids (berberine, magnoflorine), diterpenoid lactones (tinosporin, cordifolide), glycosides, steroids, and phenolics.

The anticancer potential of *T. cordifolia* is attributed to its ability to modulate the immune system, induce apoptosis in malignant cells, reduce oxidative stress, and inhibit tumor-promoting

inflammation. One of its most well-studied properties is immunomodulation; extracts of Giloy stimulate the activity and proliferation of macrophages, natural killer (NK) cells, and lymphocytes, which play a crucial role in immune surveillance and destruction of tumor cells. By enhancing both innate and adaptive immunity, *T. cordifolia* can help the body recognize and eliminate cancerous cells more effectively. Its polysaccharide-rich fractions have been shown to increase the production of interleukins (IL-2, IL-6) and tumor necrosis factor-alpha (TNF-α), cytokines that contribute to antitumor immune responses.

In addition to its immune-boosting activity, *T. cordifolia* exhibits direct cytotoxic effects against various cancer cell lines. Laboratory studies have demonstrated that extracts of Giloy can induce cell cycle arrest, particularly at the G1 phase, and trigger mitochondrial-mediated apoptosis through increased Bax/Bcl-2 ratio, activation of caspases, and release of cytochrome c. These effects result in the inhibition of cancer cell proliferation without significant harm to normal healthy cells, indicating its potential as a safe therapeutic option. Furthermore, certain diterpenoid lactones from *T. cordifolia* have been shown to interfere with tumor growth by inhibiting angiogenesis through downregulation of vascular endothelial growth factor (VEGF) expression and suppression of endothelial cell migration.

Another important mechanism by which Giloy contributes to cancer therapy is its strong antioxidant capacity. Reactive oxygen species (ROS) and oxidative DNA damage are known to play critical roles in cancer initiation and progression. The phenolic and flavonoid components of *T. cordifolia* neutralize free radicals, reduce lipid peroxidation, and restore antioxidant enzymes such as superoxide dismutase (SOD), catalase, and glutathione peroxidase, thereby protecting cells from oxidative stress-induced genetic mutations. In this way, Giloy not only acts as a preventive agent against carcinogenesis but also reduces oxidative damage during chemotherapy and radiotherapy, which often generate high levels of ROS.

Giloy's anti-inflammatory effects further strengthen its role in cancer management. Chronic inflammation is a known driver of several cancers, and *T. cordifolia* reduces this risk by downregulating pro-inflammatory mediators such as cyclooxygenase-2 (COX-2), inducible nitric oxide synthase (iNOS), and nuclear factor-kappa B (NF-κB). By inhibiting these pathways, Giloy can suppress tumor-promoting inflammation and create a less favorable environment for cancer progression.

Clinically, *T. cordifolia* is often considered as a supportive therapy for cancer patients, particularly for improving overall immunity, reducing treatment-related fatigue, and enhancing tolerance to chemotherapy and radiotherapy. Its adaptogenic properties help mitigate the physical and

psychological stress associated with cancer treatment. Some preliminary studies and patient reports suggest that Giloy supplementation may reduce the incidence of opportunistic infections during immunosuppressive cancer therapies, although larger clinical trials are required for confirmation.

In summary, *Tinospora cordifolia* plays a multifaceted role in cancer treatment by boosting immune function, inducing apoptosis in tumor cells, suppressing angiogenesis, reducing oxidative stress, and controlling chronic inflammation. Its broad-spectrum bioactivity, combined with a favorable safety profile, makes it a promising candidate for integration into complementary and supportive cancer care strategies. However, further in-depth research, including well-designed human clinical trials and standardized extract formulations, is essential to validate its therapeutic potential and establish evidence-based guidelines for its use in oncology.

4. *Andrographis paniculata* (kalmegh)

Andrographis paniculata, commonly referred to as Kalmegh or "King of Bitters," belongs to the Acanthaceae family and is rich in bioactive compounds such as **andrographolide**, neoandrographolide, and deoxyandrographolide. These diterpenoid lactones exert potent anticancer effects through modulation of multiple molecular pathways. Andrographolide has been shown to induce apoptosis by activating caspase-3 and -9, increasing Bax/Bcl-2 ratios, and releasing cytochrome c from mitochondria. It also arrests the cell cycle, often at the G0/G1 or G2/M phases, thereby inhibiting tumor cell proliferation. Andrographolide suppresses NF-κB and STAT3 signaling, reducing the expression of anti-apoptotic and pro-inflammatory genes. It exhibits anti-angiogenic effects by downregulating VEGF and inhibiting endothelial cell migration. In addition, it prevents metastasis by reducing MMP activity. Studies suggest that Andrographis may also enhance chemosensitivity and radiosensitivity of cancer cells while providing hepatoprotective and immunomodulatory benefits, making it a valuable candidate for adjunct cancer therapy.

Figure-5: *Andrographis paniculata*, commonly referred to as Kalmegh or "King of Bitters

The plant has long been used in Ayurveda, Traditional Chinese Medicine (TCM), Siddha, and Unani systems to treat a broad spectrum of ailments, including fever, infections, liver disorders, diabetes, and inflammatory diseases. The major bioactive compound of Andrographis paniculata is andrographolide, a diterpene lactone known for its anti-inflammatory, antioxidant, anticancer, antibacterial, antiviral, and immunomodulatory activities. A. paniculata is a small annual plant growing up to 30–110 cm in height, with lance-shaped leaves and small white flowers with purple markings. The leaves and aerial parts of the plant are most often used for medicinal purposes, either as crude extracts or in the form of purified compounds **Adiguna *et al*. (2023)**.

Modern pharmacological studies have provided scientific validation for many of its traditional uses. Among the most promising discoveries is its anticancer potential, where andrographolide has been shown to inhibit cancer cell proliferation, induce apoptosis, and modulate key signalling pathways such as NF-κB and STAT3, Fulda S. (2016). These findings have sparked growing interest in the development of plant-based anticancer therapies, particularly as adjuncts to conventional chemotherapy Nogueira Laiso *et al.,* (2024). Despite its bitter taste, Andrographis paniculata continues to gain attention for its therapeutic versatility, low toxicity, and broad-spectrum bioactivity, making it a valuable candidate for the development of novel herbal formulations and functional health products.

Andrographis paniculata, commonly known as Kalmegh, Green Chiretta, or the "King of Bitters," is an annual herb belonging to the family Acanthaceae, widely distributed in tropical and subtropical Asia, including India, Sri Lanka, and Southeast Asia. Traditionally used in Ayurveda, Unani, and Chinese medicine, Kalmegh is renowned for its hepatoprotective, anti-inflammatory, antipyretic, antimicrobial, and immunomodulatory properties. In recent decades, considerable scientific interest has focused on its anticancer potential, largely attributed to its principal bioactive compound **andrographolide**, along with related diterpenoid lactones and flavonoids. These compounds exhibit diverse biological activities that can suppress tumor growth, prevent metastasis, and enhance the body's immune defense mechanisms against cancer.

The anticancer effects of *A. paniculata* are mediated through multiple mechanisms, including induction of apoptosis, cell cycle arrest, anti-angiogenic activity, and modulation of immune responses. Andrographolide has been shown to trigger programmed cell death in various cancer cell lines, such as breast, colon, prostate, and leukemia cells, by activating both intrinsic (mitochondrial) and extrinsic (death receptor-mediated) apoptotic pathways. This involves upregulation of pro-apoptotic proteins such as Bax, activation of caspases-3, -8, and -9, and downregulation of anti-

apoptotic proteins like Bcl-2. Additionally, andrographolide can arrest the cancer cell cycle at G0/G1 or G2/M phases, thereby halting uncontrolled cell proliferation.

Another critical role of *A. paniculata* in cancer treatment is its anti-angiogenic activity. Tumor growth and metastasis depend heavily on the formation of new blood vessels, a process driven by vascular endothelial growth factor (VEGF) and other signaling molecules. Andrographolide has been shown to inhibit VEGF expression and suppress endothelial cell proliferation and migration, thus depriving tumors of their necessary blood supply. This anti-angiogenic effect can slow tumor expansion and limit metastatic spread.

In addition to direct cytotoxic effects on tumor cells, *A. paniculata* acts as a potent immunomodulator. It stimulates both the innate and adaptive immune systems, enhancing macrophage phagocytic activity, natural killer (NK) cell cytotoxicity, and T-lymphocyte proliferation. These immune responses help the body recognize and eliminate malignant cells more effectively. Andrographolide has also been reported to increase the production of key cytokines such as interleukin-2 (IL-2) and interferon-gamma (IFN-γ), which play essential roles in antitumor immunity.

Furthermore, *A. paniculata* possesses anti-inflammatory and antioxidant properties, which are crucial in cancer prevention and therapy. Chronic inflammation and oxidative stress are major contributors to carcinogenesis, and Kalmegh counteracts these by inhibiting pro-inflammatory mediators like NF-κB, COX-2, and TNF-α, while also scavenging reactive oxygen species (ROS) and boosting endogenous antioxidant enzymes such as superoxide dismutase (SOD) and catalase. By creating an anti-inflammatory and antioxidative microenvironment, Kalmegh reduces DNA damage and lowers the risk of tumor initiation and progression.

Experimental studies have demonstrated the efficacy of *A. paniculata* extracts and andrographolide in reducing tumor size and proliferation in animal models of cancers, including melanoma, gastric carcinoma, and hepatocellular carcinoma. In some in vitro studies, andrographolide has shown synergistic effects when combined with conventional chemotherapeutic agents, improving treatment efficacy while potentially reducing the required drug dose and associated toxicity.

Clinically, while robust large-scale trials are still lacking, *A. paniculata* is being explored as a complementary therapy in oncology for its potential to enhance patient immunity, reduce chemotherapy-induced side effects, and improve overall quality of life. Importantly, it has a favorable safety profile at therapeutic doses, although care must be taken regarding dosage standardization, as high doses may cause gastrointestinal discomfort or allergic reactions in some individuals.

In summary, *Andrographis paniculata* holds significant promise as a natural anticancer agent due to its ability to induce apoptosis, inhibit angiogenesis, suppress tumor-promoting inflammation, counter oxidative stress, and boost immune surveillance. With further research, including well-designed clinical studies and standardized extract formulations, Kalmegh could play an important role in integrative cancer therapy, serving both preventive and therapeutic purposes while minimizing harm to normal tissues.

5. *Ocimum sanctum* (Holy Basil or Tulsi)

Ocimum sanctum, or Holy Basil, is a sacred plant in India belonging to the Lamiaceae family, valued for its adaptogenic, antioxidant, and anti-inflammatory properties. Its anticancer potential is linked to bioactive constituents such as eugenol, ursolic acid, apigenin, luteolin, rosmarinic acid, and various flavonoids. Tulsi prevents carcinogenesis by scavenging ROS, enhancing endogenous antioxidant enzymes, and reducing lipid peroxidation. It downregulates inflammatory mediators (TNF-α, IL-6, COX-2) via inhibition of NF-κB signaling, thereby suppressing tumor-promoting inflammation. Tulsi extracts induce apoptosis through mitochondrial pathways, increasing Bax and p53 expression while reducing Bcl-2, and activating caspases. It also inhibits angiogenesis by reducing VEGF levels and suppresses metastasis via inhibition of MMP activity. Tulsi strengthens immune surveillance by enhancing NK cell cytotoxicity and T-cell responses. Preclinical studies have shown activity against skin, lung, liver, and breast cancers, with potential to improve chemotherapeutic efficacy and reduce side effects.

Figure-6*: Ocimum sanctum*, popularly known as Tulsi or holy basil, is a sacred plant in Hindu culture and a cornerstone in Ayurvedic medicine

Ocimum sanctum, popularly known as Tulsi or holy basil, is a sacred plant in Hindu culture and a cornerstone in Ayurvedic medicine. Belonging to the Lamiaceae family, Tulsi is recognized for its immunomodulatory, antistress, antimicrobial, and antidiabetic effects. Its essential oils, especially

eugenol, contribute to its therapeutic effects. It is widely used to manage respiratory disorders, stress-related conditions, and infections.

These plants are not only readily available and widely used in ethnomedicine but also offer a cost-effective approach to cancer treatment, particularly in resource-limited settings. The investigation of anticancer activity in medicinal plants holds immense potential to revolutionize cancer therapeutics by providing safer, multi-targeted, and more affordable options Sumit singh *et al*., 2020. This study seeks to contribute to the growing body of evidence supporting the integration of traditional medicinal knowledge with modern scientific research, paving the way for new drug discoveries and holistic cancer treatment strategies. Cancer is a leading cause of death globally. Chemotherapy has side effects; thus, plant-based therapies are gaining attention. Many medicinal plants have phytochemicals (alkaloids, flavonoids, terpenoids, saponins, etc.) with anticancer properties. Example: *Taxol* from *Taxus brevifolia*, *Vincristine* from *Catharanthus roseus*.

Ocimum sanctum, commonly known as Holy Basil or Tulsi, is a revered medicinal herb in Ayurveda, belonging to the family Lamiaceae. It is widely grown across India and Southeast Asia and holds a sacred place in traditional medicine due to its broad spectrum of therapeutic properties, including antioxidant, anti-inflammatory, antimicrobial, adaptogenic, and immunomodulatory effects. Over the past few decades, Tulsi has gained significant attention in cancer research owing to its diverse phytochemical profile, which includes ursolic acid, eugenol, rosmarinic acid, apigenin, luteolin, carnosic acid, β-sitosterol, and various flavonoids. These bioactive compounds collectively contribute to Tulsi's potential anticancer effects through multiple molecular and cellular mechanisms.

One of the primary anticancer actions of *O. sanctum* is prevention of oxidative stress and DNA damage, which are key contributors to carcinogenesis. Tulsi contains potent antioxidants that neutralize reactive oxygen species (ROS), enhance the activity of endogenous antioxidant enzymes such as superoxide dismutase (SOD), catalase, and glutathione peroxidase, and reduce lipid peroxidation. By protecting cellular DNA from oxidative injury, Tulsi reduces mutation rates and the risk of malignant transformation.

Another important mechanism is anti-inflammatory modulation, as chronic inflammation plays a central role in tumor initiation and progression. Tulsi's active compounds, particularly eugenol and ursolic acid, inhibit pro-inflammatory transcription factors such as NF-κB, and downregulate inflammatory mediators like cyclooxygenase-2 (COX-2), tumor necrosis factor-alpha (TNF-α), and interleukin-6 (IL-6). This anti-inflammatory environment not only impedes cancer initiation but also suppresses tumor-promoting microenvironments.

Tulsi also exhibits direct antiproliferative and pro-apoptotic effects against cancer cells. Studies have shown that its phytochemicals can induce apoptosis through mitochondrial pathways, characterized by upregulation of pro-apoptotic proteins (Bax, p53), downregulation of anti-apoptotic proteins (Bcl-2), activation of caspase-3 and caspase-9, and cytochrome c release. Additionally, Tulsi can cause cell cycle arrest, particularly at the G0/G1 phase, thereby preventing uncontrolled cell division. These effects have been observed in several cancer cell lines, including breast, lung, colon, prostate, and skin cancers.

Another noteworthy property of Tulsi is its anti-angiogenic effect, which inhibits the formation of new blood vessels necessary for tumor growth and metastasis. Ursolic acid and other constituents can downregulate vascular endothelial growth factor (VEGF) expression and reduce endothelial cell migration, thus starving tumors of nutrients and oxygen. Moreover, Tulsi's anti-metastatic activity involves suppression of matrix metalloproteinases (MMPs), which are enzymes responsible for degrading the extracellular matrix and facilitating cancer cell invasion.

From an immunomodulatory perspective, Tulsi enhances both innate and adaptive immune responses. It stimulates macrophage activity, promotes natural killer (NK) cell cytotoxicity, and increases T-cell proliferation. These immune-enhancing properties help the body identify and destroy abnormal cancer cells more effectively. Furthermore, Tulsi's adaptogenic nature helps in mitigating the harmful effects of stress, which is known to compromise immune function and potentially accelerate cancer progression.

Importantly, Tulsi may also enhance the efficacy and tolerability of conventional cancer therapies. Preclinical studies suggest that Tulsi extracts can sensitize cancer cells to chemotherapeutic agents and radiation, potentially allowing for lower drug doses and reduced side effects. Its strong antioxidant and anti-inflammatory effects also protect normal tissues from chemotherapy-induced oxidative damage and inflammation, thereby improving patient quality of life during treatment.

Several animal studies and in vitro experiments have demonstrated Tulsi's protective and therapeutic roles in models of skin, liver, lung, and breast cancers. While clinical evidence is still emerging, preliminary findings suggest that Tulsi can be safely incorporated as an adjunct in integrative oncology approaches, provided its use is guided by evidence-based protocols to avoid herb–drug interactions. *Ocimum sanctum* offers a multi-pronged anticancer potential preventing oxidative DNA damage, modulating inflammatory pathways, inducing cancer cell apoptosis, inhibiting angiogenesis, and boosting immune surveillance. With further research, standardization of extracts, and controlled clinical trials, Tulsi could become an important complementary agent in

cancer prevention and treatment strategies, particularly in holistic and integrative medical frameworks.

Tabl-1: Medicinal Plants with Anticancer Activity are-

Plant Name	Active Constituents	Cancer Type
Withania somnifera	Withaferin A	Lung, prostate
Tinospora cordifolia	Tinosporaside, Cordifolioside	Colon, breast
Andrographis paniculata	andrographolide, a labdane diterpenoid	Oral, colon, breast, and leukemia.
Ocimum sanctum	Eugenol, Ursolic acid, Rosmarinic acid	Skin, liver, breast, and lung cancers
Curcuma longa	Curcumin	Breast, colon, prostate, lung, and pancreatic cancers.

Table 2. Statistics of type of medicinal plants used for the treatment of Cancer

S.N.	Name of Plants	No. of plants used
1	*Withania somnifera*	80
2	*Tinospora cordifolia*	90
3	*Andrographis paniculata*	10
4	*Ocimum sanctum*	90
5	*Curcuma longa*	50

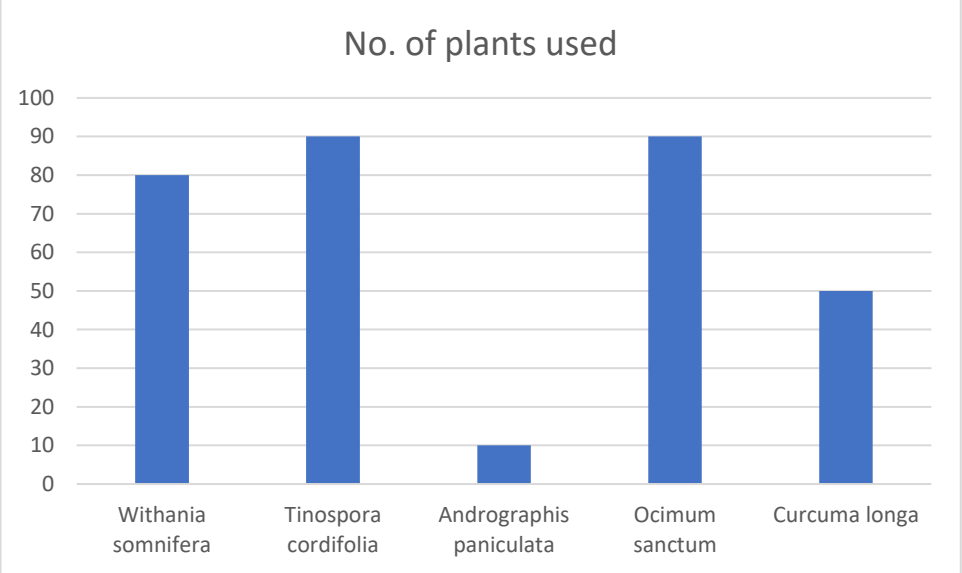

Figure-7*:* Graphical representation of medicinal plants used for the treatment of Cancer

Conclusion:

There are many traditional systems of medicine in the world, each with different associated philosophies and cultural origins. Some of these, such as Tibetan traditional medicine, remain relatively localised in their country of origin; while others such as Ayurvedic and Chinese traditional medicines are increasingly used in many different areas of the world. This paper will concentrate on the issue treatment of chronic diseases and heavy metal poisoning related to herbal traditional medicines. Medicinal plants in India represent an invaluable heritage, deeply rooted in traditional healing systems such as Ayurveda, Siddha, and Unani. With its rich biodiversity, India is home to thousands of plant species known for their therapeutic potential, many of which continue to be used in primary healthcare, both in rural and urban communities. These plants serve as a vital source of bioactive compounds for modern drug discovery, offering remedies for chronic and emerging diseases alike. However, overexploitation, habitat loss, and lack of proper conservation strategies pose significant challenges to their sustainable use. Strengthening scientific validation, promoting sustainable harvesting, and integrating traditional knowledge with modern research are essential for preserving this natural wealth. Thus, medicinal plants not only contribute to India's cultural and healthcare systems but also hold immense promise for future global pharmacological advancements.

References

1.Wang M, Li Y, Pan T, et al. Plant natural compounds in the cancer treatment: a systematic bibliometric analysis. Heliyon. 2024;10(14):e34462.

2.Garcia-Oliveira P, Otero P, Pereira AG, et al. Status and challenges of plant-anticancer compounds in cancer treatment. Pharmaceuticals. 2021;14(2):157.

3.Talib WH, Daoud S, Mahmod AI, et al. Plants as a source of anticancer agents: from bench to bedside. Molecules. 2022;27(15):4818.

4. Shrihastini V,Muthuramalingam P, Adarshan S, et al. Plant derived bioactive compounds, their anti-cancer effects and in silico approaches as an alternative target treatment strategy for breast cancer: an updated overview. Cancers (Basel). 2021;13(24):6222.

5.Hu, Y., and Reggiori, F. (2022). Molecular regulation of autophagosome formation. Biochem. Soc. Trans. 50, 55–69. doi:10.1042/BST20210819

6.Huang, Y., Wang, G., Zhang, N., and Zeng, X. (2024). MAP3K4 kinase action and dual role in cancer. Discov. Oncol. 15, 99. doi:10.1007/s12672-024-00961-x

7. S. M. Mousavi, S. A. Hashemi, G. Behbudi et al., "A review on health benefits of Malva sylvestris L. nutritional compounds for metabolites, antioxidants, and anti-inflammatory, anticancer, and

antimicrobial applications," Evidence-based complementary and alternative medicine: eCAM, vol. 2021, article 5548404, 13 pages, 2021.

8. J. Fares, M. Y. Fares, H. H. Khachfe, H. A. Salhab, and Y. Fares, "Molecular principles of metastasis: a hallmark of cancer revisited," Signal Transduction and Targeted Therapy, vol. 5, no. 1, p. 28, 2020.

9.Singh A, Singh GS, Singh P (2012). Medico-ethnobotanical inventory of Renukoot forest division of district Sonbhadra, Uttar Pardesh, India. Indian J. Nat. Prod. Res. 3(3):448-457.

10.Viljoen, A.; Sandasi, M.; Vermaak, I. The role of the South African Journal of Botany as a vehicle to promote medicinal plant research–A bibliometric appraisal. S. Afr. J. Bot. **2019**, 122, 3–10. [CrossRef]

11. Kamte, S.L.N.; Ranjbarian, F.; Campagnaro, G.D.; Nya, P.C.B.; Mbuntcha, H.; Woguem, V.; Benelli, G. Trypanosoma brucei inhibition by essential oils from medicinal and aromatic plants traditionally used in Cameroon (Azadirachta indica, Aframomum melegueta, Aframomum daniellii, Clausena anisata, Dichrostachys cinerea and Echinops giganteus). Int. J. Environ. Res. Public Health **2017**, 14, 737. [CrossRef]

12. Esther Salmerón-Manzano 1, Jose Antonio Garrido-Cardenas 2 and Francisco Manzano-Agugliaro Worldwide Research Trends on Medicinal Plants Int. J. Environ. Res. Public Health 2020, 17, 3376; doi:10.3390/ijerph17103376

13. Kuldip S. Dogra1*, Sandeep Chauhan1 and Jeewan S. Jalal2 Assessment of Indian medicinal plants for the treatment of asthma Journal of Medicinal Plants Research Vol. 9(32), pp. 851-862, 25 August, 2015 DOI: 10.5897/JMPR2015. 5890

14. Charles C. Davis1,* and Patrick Choisy2 Medicinal plants meet modern biodiversity science Current Biology 34, R158–R173, February 26, 2024 R159

15. Yuvenalis M. Mbuni 1,2,3, Shengwei Wang 1,2,4 , Brian N. Mwangi 1,2, Ndungu J. Mbari 1,2 ,Paul M. Musili 3, Nyamolo O. Walter 3, Guangwan Hu 1,4,5, Yadong Zhou 1,4,5,* andQingfeng Wang 1,4,5 Medicinal Plants and Their Traditional Uses in Local Communities around Cherangani Hills, Western Kenya Plants 2020, 9, 331; doi:10.3390/plants9030331

16. M. Umadevi1, K.P.Sampath Kumar2, Debjit Bhowmik3*, S. Duraivel4 Traditionally Used Anticancer Herbs In India Journal of Medicinal Plants Studies 2013, Volume: 1, Issue: 3 (56) Last page: (74)ISSN: 2320-3862 Online Available at www.plantsjournal.com