

8. Medicinal Plants: Anti-Cancer Role

**Nzanthung Ezung, Shune Movi,
Atsungpong Longchar**

Department of Horticulture,
SAS: NU - Medziphema, Nagaland.

Abstract

This chapter explores the potential of medicinal plants as sources of anti-cancer agents, drawing upon traditional medicinal practices along with modern scientific research. Cancer remains a formidable worldwide health challenge, necessitating the exploration of alternative therapeutic approaches. Traditional medicine systems have long relied on the healing properties of plants to treat various ailments, including cancer, providing a rich foundation for modern scientific investigation. Through various scientific trials, numerous bioactive compounds derived from medicinal plants have been identified for their potential anti-cancer effects, including apoptosis induction, cell cycle arrest, anti-angiogenic activity, and modulation of signaling pathways. Case studies highlight the anti-cancer properties of specific medicinal plants such as turmeric, garlic, periwinkle, kokum, and green tea, supported by preclinical and clinical evidence. However, challenges such as standardization of herbal extracts, dosage determination, and potential interactions with conventional cancer treatments must be addressed. Overall, medicinal plants represent promising sources of anti-cancer agents, offering novel avenues for cancer prevention, treatment, and management. Collaboration between traditional medicine practitioners, scientists, and healthcare professionals is crucial to harnessing the full therapeutic potential of medicinal plants in the fight against cancer.

Keywords:

Medicinal plants, Anti-cancer, Bioactive compounds, traditional medicines.

8.1 Introduction:

Cancer remains one of the most challenging health issues worldwide, with significant social and economic burdens. Traditional medicine systems, spanning various cultures and civilizations, have long relied on the healing properties of plants to combat various ailments, including cancer. This chapter aims to delve into the potential of medicinal plants in the fight against cancer, exploring their bioactive compounds, mechanisms of action, case studies, challenges, and prospects.

8.2 Understanding Cancer and Traditional Medicine:

Cancer is characterized by the uncontrolled growth and spread of abnormal cells, resulting in the formation of malignant tumors which ultimately leads to cancerous cell formation.

Traditional medicinal practices, rooted in centuries-old knowledge, have often incorporated plant-based remedies to treat various diseases which include cancer. Across different cultures around the world, indigenous healers and traditional medicine practitioners have utilized the therapeutic properties of plants to alleviate symptoms and improve outcomes for various ailments and even cancer patients. These traditional remedies serve as a valuable foundation for modern research into the anti-cancer potential of medicinal plants.

8.3 Identification of Anti-Cancer Compounds in Medicinal Plants:

Medicinal plants are rich sources of bioactive compounds that exhibit diverse pharmacological activities, including anti-cancer properties. Through rigorous scientific investigations and trials, researchers have identified numerous compounds with potential anti-cancer effects, such as alkaloids, flavonoids, polyphenols, terpenoids, and alkaloids. Examples of well-known anti-cancer compounds derived from medicinal plants include taxol, obtained from the bark of the Pacific yew tree (*Taxus brevifolia*), and vincristine, extracted from the periwinkle plant (*Catharanthus roseus*). These compounds have been extensively studied for their ability to inhibit cancer cell proliferation, induce apoptosis (programmed cell death), and interfere with various cellular signaling pathways involved in cancer development and progression.

8.4 Mechanisms of Action:

The anti-cancer effects of medicinal plants are mediated through multiple mechanisms, reflecting the complexity of cancer biology. These mechanisms include:

- **Induction of apoptosis:** Many bioactive compounds derived from medicinal plants possess the ability to trigger programmed cell death in cancer cells, thereby inhibiting tumor growth.
- **Cell cycle arrest:** Certain plant-derived compounds can disrupt the cell cycle progression of cancer cells, leading to their accumulation and eventual demise.
- **Anti-angiogenic effects:** Angiogenesis, the process of new blood vessel formation, is essential for tumor growth and metastasis. Some medicinal plant compounds exhibit anti-angiogenic properties, suppressing the formation of blood vessels within tumors and limiting their nutrient supply.
- **Modulation of signaling pathways:** Plant-derived compounds can interfere with key signaling pathways involved in cancer development and progression, including those regulating cell proliferation, survival, migration, and invasion.

8.5 Case Studies:

Numerous medicinal plants have been studied for their potential anti-cancer properties, with promising findings reported in both preclinical and clinical studies. Some notable examples include:

- **Aloe vera (*Aloe barbadensis*):** It belongs to the Asphodelaceae family and contains bioactive compounds like aloe-emodin and aloin in its leaves.

Research suggests that these compounds can inhibit metastasis and the spread of cancer cells to other parts of the body. Additionally, Aloe vera has been shown to enhance the immune system, which plays a crucial role in defending the body against cancer and other diseases.

- **Arborvitae/white cedar (*Thuja occidentalis*):** It belongs to the Cupressaceae family, possesses medicinal properties that have been recognized for centuries. Extracts from its leaves contain thujone, a compound that has been studied for its potential therapeutic effects. Recent research has shown that thujone can decrease cell viability, meaning it may inhibit the growth of abnormal or cancerous cells. Moreover, thujone exhibits pro-apoptotic properties, meaning it can induce programmed cell death, which is crucial for eliminating damaged or abnormal cells from the body. Additionally, studies have suggested that thujone promotes the regression of neoplasia, indicating its potential in halting or reversing the growth of tumors.
- **Asafoetida or Devil's Dung (*Ferula asafoetida*):** It belongs to the Apiaceae family, possesses notable medicinal properties, particularly in traditional medicine practices. Both the shoot and resin of *Ferula asafoetida* contain bioactive compounds such as sesquicoumarin, oleic acid, and β -sitosterol, which have been investigated for their potential health benefits. Recent studies have demonstrated that these compounds exhibit inhibitory effects on mutagenesis, the process by which genetic mutations occur, and the proliferation of cancer cells. By targeting mutagenesis and cancer cell growth, *Ferula asafoetida* shows promise as a natural remedy for preventing cancer development and progression.
- **Asiatic Pennywort (*Centella asiatica*):** It contains asiaticoside and asiatic acid, compounds that induce apoptosis, or programmed cell death. This ability to inhibit cell growth suggests its potential as a natural anti-cancer agent.
- **Bitter Melon (*Momordica charantia*):** It belongs to the Cucurbitaceae family and contains bioactive compounds such as momorcharins, momordicine, and charantin in its fruits. These compounds have been found to induce autophagy, apoptosis, and cell cycle arrest in cancer cells.
- **Black cumin (*Nigella sativa*):** It belongs to the Ranunculaceae family, is esteemed for its medicinal properties, particularly in traditional medicine systems. Within its seeds, compounds such as thymoquinone and dinitroquinone have been identified as potent bioactive agents. Recent research has elucidated the ability of these compounds to induce apoptosis, a programmed cell death mechanism essential for eliminating damaged or abnormal cells from the body. Additionally, thymoquinone and dinitroquinone have been shown to cause cell cycle arrest, halting the proliferation of cancerous cells at various stages of the cell cycle.
- **Clove (*Eugenia aromatic*):** It belongs to the Myrtaceae family, is celebrated for its aromatic flower buds and diverse medicinal properties. Within its buds, compounds such as eugenol, carvacrol, thymol, and anthocyanins contribute to its therapeutic effects. Recent research has shed light on the ability of clove extracts to inhibit and arrest the growth of cancerous cells. These compounds have demonstrated promising anti-cancer properties, showing effectiveness in suppressing the proliferation of abnormal cells and halting their progression.
- **Foxglove (*Digitalis purpurea*):** It belongs to the Plantaginaceae family, is esteemed for its medicinal properties, particularly in the treatment of heart conditions. Within its leaves, compounds such as gitoxigenin and gitoxin play a significant role in its

pharmacological effects. Recent studies have highlighted the potential of Foxglove compounds in inducing apoptosis, a programmed cell death mechanism essential for maintaining healthy cellular processes. The ability of *Digitalis purpurea* to trigger apoptosis has implications for cancer treatment, as targeted cell death can help suppress tumor growth and progression.

- **Garlic (*Allium sativum*):** It belongs to the Liliaceae family, is renowned for its bulbous structure. Within its cloves, compounds such as allicin, alliin, and allixin contribute to its medicinal properties. Among its numerous health benefits, garlic has been found to enhance the activity of macrophages, which are key players in the immune system responsible for engulfing and destroying pathogens. Additionally, research suggests that garlic may have potential in inhibiting metastases, the spread of cancer from one organ to another.
- **Ginger (*Zingiber officinale*):** It contains bioactive compounds like curcumin, gingerenone A, gingerols, and zingerone in its rhizomes. Among these, curcumin and gingerols show potential anti-cancer effects. Studies indicate that ginger extracts can inhibit cancer cell growth by inducing apoptosis, reducing DNA synthesis, and arresting the cell cycle at the G0/G1 phase.
- **Green Tea (*Camellia sinensis*):** It belongs to the Theaceae family, and yields bioactive compounds such as epicatechin, epigallocatechin, epigallocatechin gallate (EGCG), and epigallocatechin-3-gallate (EGCG-3-G). These compounds are renowned for their ability to inhibit the proliferation of cancer cells. Green tea extracts have been extensively studied for their anti-cancer properties, particularly due to the presence of EGCG, which has shown promising results in suppressing the growth and spread of cancer cells.
- **Guava (*Psidium guajava*):** It belongs to the Myrtaceae family, and offers bioactive compounds found in both its fruits and leaves extract, including quercetin 3-glucuronide, d-glucuronic acid, and xanthyletin. Studies suggest that these compounds exhibit inhibitory effects on cancer cells by modulating various signaling cascades. Additionally, guava extracts have been shown to induce tumor growth suppression.
- **Heart-leaved moonseed (*Tinospora cordifolia*):** It belongs to the Menispermaceae family, is renowned for its medicinal properties in various traditional medicine systems. The whole herb of *Tinospora cordifolia* contains bioactive compounds such as tinosporine and berberine, which have been studied for their therapeutic effects. Recent research has shown that these compounds can cause the activation of macrophages, which are key immune cells responsible for engulfing and destroying pathogens. By activating macrophages, *Tinospora cordifolia* enhances the immune response, thereby bolstering the body's ability to defend against infections and diseases.
- **Hemp (*Cannabis sativa*):** It belongs to the Cannabinaceae family and contains cannabinoids such as cannabidiol in its leaves. These compounds have been found to induce cancer cell death through apoptosis and inhibit the proliferation of cancer cells.
- **Kokum (*Garcinia indica*):** It belongs to the Clusiaceae family and contains bioactive compounds such as garcinol, isogarcinol, and Cyanidin-3-glucoside in its fruits. These compounds have been identified for their ability to induce apoptosis or programmed cell death. Research suggests that *Garcinia indica* extracts may trigger apoptosis in cancer cells, highlighting its potential as a natural agent for inhibiting tumor growth and progression.
- **Liquorice (*Glycyrrhiza glabra*):** It belongs to the Leguminosae family, boasts a range of medicinal properties. Extracts from the plant, particularly glycyrrhizin, have

garnered attention for their therapeutic potential. Studies have shown that glycyrrhizin exhibits properties that can inhibit abnormal cell proliferation, making it a promising candidate in the fight against various types of cancer. Additionally, research suggests that liquorice extracts may help prevent tumor formation, offering hope for novel cancer treatments.

- **Madagascar periwinkle (*Catharanthus roseus*):** It belongs to the Apocynaceae family. The dried whole plants of *Catharanthus roseus* contain vinblastine and vincristine, two bioactive compounds known for their anti-cancer properties. These compounds act as anti-mitotic and anti-microtubule agents, disrupting the process of cell division and hindering the growth of cancer cells.
- **Mayapple (*Podophyllum hexandrum*):** It contains podophyllotoxin, asiragalin, and podophyllin in its roots and rhizomes. These compounds arrest the multiplication of cancerous cells by disrupting microtubule formation, highlighting Mayapple's potential as a natural agent for inhibiting cancer cell growth.
- **Neem (*Azadirachta indica*):** It belongs to the Meliaceae family and possesses bioactive compounds like azadirachtin and nimbolide in its leaves. These compounds are recognized for their potential as tumor suppressors. Research suggests that *Azadirachta indica* extracts containing azadirachtin and nimbolide may exert inhibitory effects on tumor growth and progression.
- **Silver Birch (*Betula pendula*):** It belongs to the Betulaceae family and possesses bioactive compounds such as betulin and betulinic acid in its bark. These compounds have been identified for their ability to inhibit the growth of cancer cells. This suggests the potential of Silver Birch as a natural agent for suppressing cancer cell proliferation.
- **Thyme (*Thymus vulgaris*):** It belongs to the Lamiaceae family and contains bioactive compounds such as thymol and carvacrol in its shoots. These compounds have been found to induce cell cycle arrest. This suggests the potential of Thyme as a natural agent for halting the progression of the cell cycle in cancer cells.
- **Turmeric (*Curcuma longa*):** A member of the Zingiberaceae family, is renowned for its medicinal properties primarily found in its rhizomes. Studies have demonstrated that curcumin possesses apoptotic properties, triggering programmed cell death in cancer cells.
- **Winter cherry or Ashwagandha (*Withania somnifera*):** It belongs to the Solanaceae family. Its roots contain bioactive compounds like Withaferin A and Withanolide D. Research indicates that these compounds can inhibit the growth and spread of various cancers.

8.6 Challenges and Considerations:

Despite the promising potential of medicinal plants in cancer treatment, several challenges and considerations must be addressed which are as follows:

- **Standardization of herbal extracts:** The composition of herbal extracts can vary widely depending on factors such as plant species, growing conditions, harvesting methods, and extraction processes. Standardization of herbal products is essential to ensure consistency in potency and efficacy.
- **Dosage determination:** Determining the optimal dosage of medicinal plant extracts for cancer treatment requires careful consideration of factors such as bioavailability,

toxicity, and individual patient characteristics. Clinical studies are needed to establish safe and effective dosage regimens.

- **Potential interactions with conventional cancer treatments:** Medicinal plant compounds may interact with conventional cancer therapies, such as chemotherapy and radiation therapy, affecting their efficacy and safety. Close monitoring and coordination between traditional and modern healthcare practitioners are necessary to minimize the risk of adverse interactions.

8.7 Future Directions and Conclusion:

The exploration of medicinal plants as potential sources of anti-cancer agents represents a promising avenue for cancer research and drug development. Future studies should focus on:

- Identifying novel bioactive compounds from medicinal plants with enhanced anti-cancer properties and improved pharmacokinetic profiles.
- Conducting rigorous preclinical and clinical trials to evaluate the efficacy and safety of medicinal plant extracts and compounds in cancer treatment.
- Exploring synergistic interactions between medicinal plant compounds and conventional cancer therapies to enhance treatment outcomes and minimize side effects.

In conclusion, medicinal plants hold significant potential as valuable sources of anti-cancer agents, offering novel avenues for cancer prevention, treatment, and management. However, further research and collaboration between traditional medicine practitioners, scientists, and healthcare professionals are essential to harness the full therapeutic potential of medicinal plants in the fight against cancer.

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