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# Therapeutic Potential Of Neem (*Azadirachta Indica*): A Review Of Its Bioactive Compounds And Anticancer Properties.

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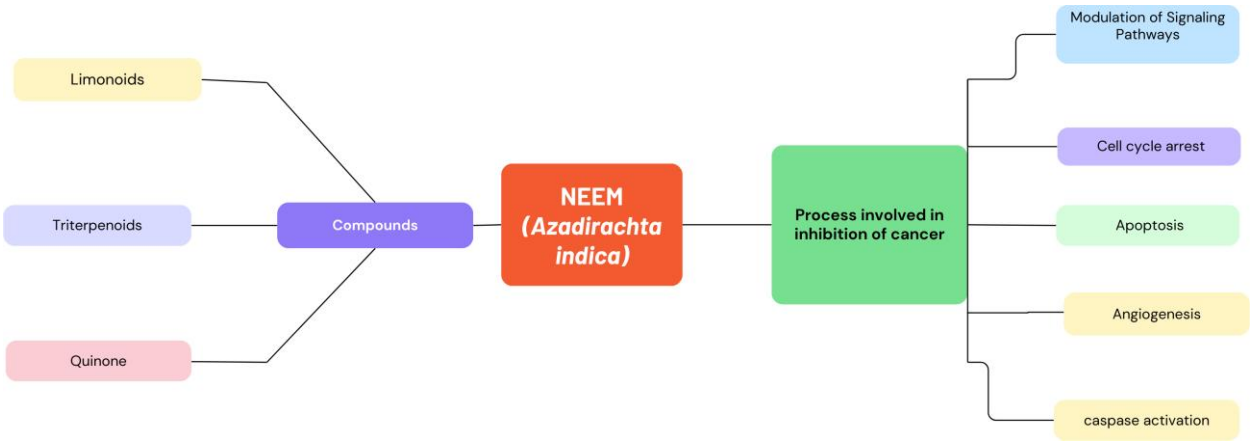
**Abstract:**
The neem tree, native to the Indian subcontinent, has been pivotal in traditional medicine for ages. Neem, scientifically known as *Azadirachta indica*, contains a multitude of useful chemicals that are being investigated for their anti-cancer properties. The anticancer properties of these drugs, highlighting their unique structural features and methods of action. Azadirachtin, once acknowledged for its pesticidal properties, has novel potential as an anti-inflammatory and anticancer drug. Phytoconstituents like Gedunin, acting as an HSP90 inhibitor, demonstrates significant effects on gastric cancer cells. Nimbin, classified as a limonoid, exhibits protective properties against oxidative stress, especially in circumstances such as polycystic ovarian syndrome. Beta-sitosterol, a triterpenoid, is examined for its capacity to induce apoptosis in several cancer cells. This review thoroughly examines their modes of action, including apoptotic induction, caspase activation, cell cycle arrest, and signaling pathway regulation, so providing a solid basis for future research and development efforts. The findings suggest that neem may serve as a viable complementary or alternative therapy in the broad field of cancer treatment. This review examines the bioactive compounds derived from the neem tree and their potential applications in cancer treatment. The focus is on its bioactive constituents, including limonoids, triterpenoids, and quinones, highlighting essential components such as azadirachtin, gedunin, nimbin, and beta-sitosterol.

**Keywords**
**Anti-cancer, Anti-inflammatory bioactive compounds, Phytoconstituents, Cell Cycle**
**Graphical abstract**




## Introduction:

The neem tree, native to the Indian subcontinent, has been pivotal in traditional medicine for ages. Neem (*Azadirachta indica*) has been recognised for its medicinal properties since the inception of plant species. In the Indian subcontinent, this tree has a longstanding designation as a "wonder tree." Since the era of the Vedic civilization, neem has been utilised therapeutically in many ways in India. Nearly all components of trees, such as the trunk, bark, roots, foliage, resin, seeds, fruits, and blossoms, have been utilised as traditional remedies for various human ailments since antiquity. Scientific research has thoroughly examined the bioactive chemicals of the neem tree, revealing their potential usefulness in cancer therapy. Limonoids, a class of chemicals prevalent in neem, including azadirachtin, epoxyazadiradione, gedunin, and nimbolide, have been thoroughly investigated for their significant anticancer properties. Nimbolide, characterised by its unique structural features, has demonstrated significant potential in suppressing cancer cell proliferation. Azadirachtin, a notable chemical derived from neem, is not only an efficient pesticide but also exhibits anti-inflammatory and anticancer properties. Its capacity to mitigate pro-inflammatory responses in pancreatic beta cells and suppress elevated inflammatory signals underscores its multifaceted potential as a multi-targeted strategy in cancer treatment.[1].

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Gedunin, a phytochemical produced from neem, has attracted interest for its impact on stomach cancer. Gedunin demonstrates significant anticancer potential by impairing cell viability and inducing oxidative stress. Its role as an inhibitor of Heat Shock Protein 90 (HSP90) adds a distinct aspect to its anticancer action.
Quinones derived from neem, despite their limited use owing to possible harmful side effects, have garnered acknowledgement as constituents in many anticancer medicines [4].

This comprehensive review aims to provide an in-depth analysis of the bioactive chemicals present in neem and their potential applications in cancer therapy. The review establishes a foundation for ongoing research and development in utilising neem as a complementary or alternative cancer therapy by examining its mechanisms of action, including apoptosis induction, caspase activation, cell cycle arrest, and signalling pathway modulation. Historically, neem tree compounds have been extensively utilised in health management due to their extensive health-enhancing properties. The review delineates Neem's medicinal effects in both therapy and prevention of several ailments.

**Botanical Classification of Plant**
The neem tree develops rapidly, reaching heights of 15 to 20 meters, and features small, vibrant green leaves. It is prevalent in tropical and semi-tropical regions. It blossoms in the spring with an abundance of white flowers. They thrive in areas characterised by poor soils and an annual precipitation of 400–800 mm. The neem plant was regarded as highly valuable and remarkable, playing a crucial role in India. It is classified botanically as follows:

**Classification of Plant**

| | |
|---|---|
| Order | Rutales |
| Suborder | Rutinae |
| Family | Meliaceae |
| Subfamily | Melioideae |
| Tribe | Melieae |
| Genus | Azadirachta |
| Species | indica |
| Latin | *Azadirachta indica* |

**Bioactive Arsenal of Neem.**
**1. Limonoids**
The neem tree (Azadirachta indica A. Juss.) contains a class of bioactive substances that has attracted growing interest in scientific research. Neem limonoids, such as azadirachtin, epoxyazadiradione, gedunin, and nimbolide, have been extensively studied for their potential as anticancer drugs.
Nimbolide is a tetranortriterpenoid limonoid predominantly present in the leaves and flowers of the neem tree. The molecular formula is C27H30O7, and the chemical structure is specified as (4a,5a,6a,7a,15b,17a).-7, 15:21, 23-diepoxy-6-hydroxy-4,8-dimethyl-1-oxo-18,24-dinor-11,12-secochola-2,13,20,22-tetraene-4,11-dicarboxylic acid γ-lactone methyl ester.</text
Nimbolide, categorised as a limonoid, displays unique structural characteristics associated with its anticancer properties. The importance of the α,β-unsaturated ketone and γ-lactone constituents is highlighted for their activity. The examination of amide derivatives indicates potential structural modifications to enhance nimbolide's cytotoxic effects on cancer cells.

**2 Azadirachtin**
Azadirachtin (AZD), derived from the medicinal Neem tree (Azadirachta indica), is a notable bioactive molecule recognised for its diverse applications, including its function as a pesticide and its significant anti-inflammatory and anti-cancer properties. Azadirachtin (AZD), a phytochemical extracted from neem, exhibits anti-cancer properties by mitigating pro-inflammatory reactions induced by bacterial endotoxin (LPS) in insulin-secreting pancreatic beta cells (Rin-5F). This function impedes the amplification of inflammatory signals, aiding in the preservation of cellular homeostasis. AZD, possessing well-documented anti-inflammatory, anticancer, and antioxidant properties, presents itself as a multifaceted molecule with prospective uses in immunotherapy and cancer management. The study emphasises the significance of focussing on microbial products, cytokines, and inflammatory macrophages in cancer treatment, with AZD emerging as a promising drug in this context.

**3. Gedunin**
Gedunin, a natural compound derived from the neem tree (Azadirachta indica), was specifically investigated for its effects on gastric cancer, focussing on AGS cells. The administration of gedunin exhibited substantial effects on AGS cells, resulting in a pronounced decrease in cell viability and the suppression of growth and proliferation. The treatment of gedunin induced oxidative stress in AGS cells, evidenced by an increased formation of reactive oxygen species

(ROS), a hallmark typically linked to cellular damage and extensively documented in several anticancer approaches. The results demonstrated that gedunin prompted apoptosis in AGS cells [11].
The Cedar Mangrove, or 'Xylocarpus granatum,' is a tree native to the Indian subcontinent, employed for the extraction of Gedunin. [12]. Gedunin's anti-cancer action primarily depends on its function as an inhibitor of Heat Shock Protein 90 (HSP90). Gedunin inactivates HSP90 by directly binding to p23/PTGES3, a crucial component of the HSP90 machinery, hence affecting vital cellular activities. This particular inhibitor targets HSP90, an essential chaperone critical for cellular homeostasis and linked to cancer progression.

**4. Nimbin**

It trigger cell cycle arrest in the G0/G1 phase, a prevalent strategy to inhibit cancer cell proliferation, significantly amplifies the anti-cancer efficacy of Nimbin and Nimbic acid. The initiation of the caspase cascade, especially the elevated expression of Caspase 3 and Caspase 9, signifies the activation of apoptosis in neoplastic cells. Caspases, essential enzymes for programmed cell death, underscore the compounds' potential as effective agents in inducing apoptosis in cancer cells.[14]. The anti-cancer efficacy of Nimbin (N1) and its semi-synthetic derivative Nimbic acid (N3), sourced from Azadirachta indica, was evaluated against MG-63 Osteosarcoma cells. The results indicate a substantial correlation between Nimbin and its analogue, Nimbic acid, and their impact on cancer cells. Both compounds shown considerable cytotoxicity towards MG-63 osteosarcoma cells, while showing non-toxicity to normal L6 cells (rat skeletal muscle). This selective cytotoxicity suggests a potential therapeutic benefit, as it specifically targets cancer cells while preserving normal cells from harm.[14].
Research has examined nimbin's efficacy in mitigating oxidative stress caused by testosterone, especially in circumstances such as polycystic ovary syndrome (PCOS). In circumstances where testosterone exposure impaired antioxidant enzymes and increased reactive oxygen species (ROS) levels, nimbin had a protective effect. This was shown in both laboratory investigations utilising Chinese Hamster Ovarian cells (CHO) and an in vivo PCOS zebrafish model. The Nimbin intervention led to a significant reduction in reactive oxygen species (ROS) and apoptosis in CHO cells, suggesting its capacity to mitigate testosterone-induced oxidative stress.
Nimbin demonstrated improvements in the Gonado Somatic Index (GSI) and elevated the production of the SOD enzyme in zebrafish ovaries. Moreover, it reinstated follicular maturation in histopathological analyses, mitigating the consequences of testosterone-induced maturation arrest. Gene expression investigations indicated that nimbin may exert a regulatory influence on essential PCOS-related genes, such as Tox3 and Dennd1a[16].
Nimbin exhibits a protective function against testosterone-induced oxidative stress, as evidenced in cellular and zebrafish models. This underscores its therapeutic promise in treating illnesses linked to hormonal imbalances, such as polycystic ovarian syndrome (PCOS).

**5. Triterpenoids**

Azadirachta indica, widely known as Neem, is a substantial source of triterpenoids, providing a variety of more than 150 tetranortriterpenoids with unique structural configurations. These chemicals, originating from various components of the Neem tree, can be categorised as ring-intact and C-seco triterpenoids. Instances of C-seco triterpenoids present in Neem include azadirachtin, nimbin, and salannin. The extract derived from Riceberry bran contains sterols and triterpenoids, such as campesterol, stigmasterol, β-sitosterol, and 24-methylenecycloartanol. In vitro biological evaluations indicate that gramisterol is a significant anti-cancer lead component in Riceberry bran extract.

**6. Beta Sitosterol-**

β-Sitosterol (BS), a notable bioactive compound present in many plants and vegetables, has exhibited considerable anticancer properties against multiple human cancer cell lines. Nonetheless, the exact mechanism of its action on NSCLC tumours remains inadequately clarified. BS was observed to trigger apoptosis exclusively in NCI-H460 cells, which possess wild-type p53, but it did not affect NCI-H23 cells with mutant p53. The noted down-regulation of Trx/Trx1 reductase significantly contributed to the buildup of reactive oxygen species (ROS) triggered by BS, resulting in mitochondrial-mediated apoptotic cell death in A549 and NCI-H460 cells. These findings suggest a new anticancer mechanism for β-sitosterol, indicating its potential as an effective chemotherapeutic treatment for non-small cell lung cancer (NSCLC)[19].
The resistance to apoptosis, a programmed cell death mechanism, is a common trait found in human cancer cells.The administration of beta-sitosterol has been proposed to progressively hinder the malignant properties of CaSki and HeLa cells. The findings indicate a reduction in the expression of proliferating cell nuclear antigen (PCNA) in CaSki and HeLa cells after beta-sitosterol therapy, signifying an anti-proliferative effect. This indicates that beta-sitosterol may inhibit DNA synthesis in these cells, resulting in the reduction of cell proliferation. A study by Baeka et al. suggests that beta-sitosterol significantly reduces the viability of p53-deficient human lung cancer Calu-6 cells[21].
Tumour cells exhibit irregularities in shape, metabolism, and function, frequently demonstrating impaired differentiation and maturation capabilities. In vitro, tumour cell lines exhibit traits including indefinite passage and an impairment in apoptosis. Thus, a crucial element of anti-tumor therapy is the inhibition of tumour cell proliferation. Multiple studies have indicated positive results with beta-sitosterol (SIT) treatment in achieving this goal[22].

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**7. Quinone**

Quinones are found in oil extracts obtained from neem leaves [23]. Quinones play a crucial role in medicine, especially in cancer therapy. Numerous anticancer drugs integrate quinones as essential constituents. [19].

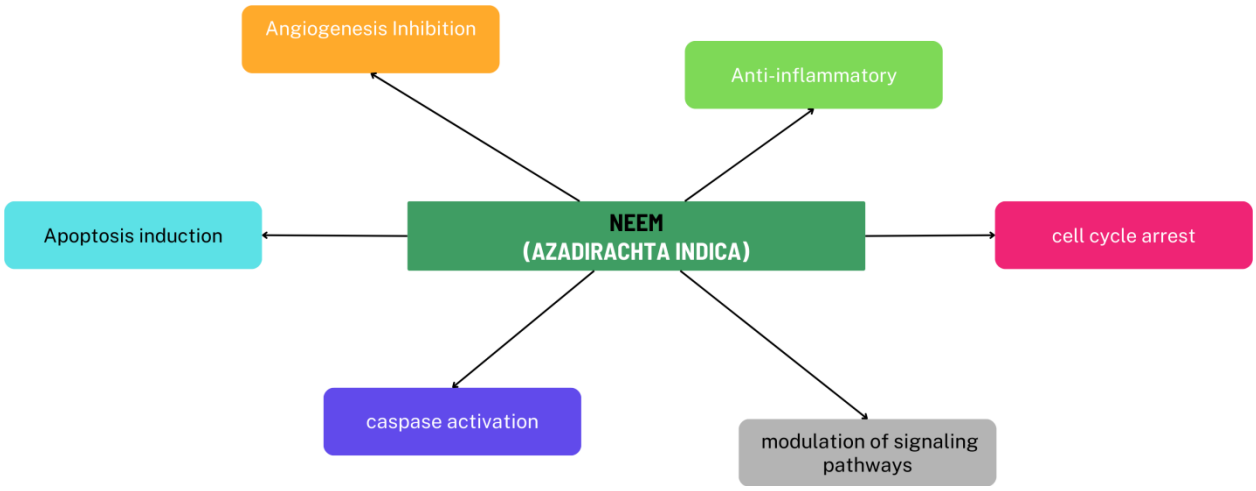
**Table1:Quinone containing drugs show promise in cancer therapy**

| Sr. No. | Quinone | Drug |
|---|---|---|
| 1. | Benzanthraquinones | Adriamycin, daunorubicin, rubidazone, nogalamycin |
| 2. | Naphthoquinones | Lapachol, menadione, Synkavit |
| 3. | N-Heterocyclic quiñones | Mitomycin C, streptonigrin |

The utilisation of quinones as anticancer medicines is limited by their possible harmful side effects. Certain effects may or may not correlate with the production of oxygen radicals, as illustrated by instances of Adriamycin-induced cardiotoxicity.

Naphthoquinones are chemical entities recognised for their varied pharmacological actions, encompassing anticancer, analgesic, anti-inflammatory, antimalarial, antifungal, antiviral, antitrypanosomal, antischistosomal, leishmanicidal, and anti-ulcerative activities. Naphthoquinones function in anticancer mechanisms by causing DNA damage via the generation of reactive oxygen species (ROS). They also demonstrate the capacity to block topoisomerase II and regulate the function of the tumour suppressor protein p53. The diverse roles of reactive oxygen species in cancer-related pathways have been thoroughly examined[24].

Azadirone, a limonoidal tetranortriterpene, demonstrates anticancer effects by enhancing the sensitivity of human tumour cells to TRAIL (Tumour Necrosis Factor-Related Apoptosis-Inducing Ligand). The limonoid stimulates the production of death receptors (DR) 5 and DR4 in cancer cells, especially activating ERK and upregulating the transcription factor CCAAT enhancer-binding protein homologous protein (CHOP). The cancer cell-specific effect entails the production of reactive oxygen species (ROS), and the elimination of ROS mitigates the influence of azadirone on ERK activation, CHOP up-regulation, DR induction, and TRAIL sensitisation. The anticancer process involves the down-regulation of cell survival proteins, up-regulation of pro-apoptotic proteins, and a synergistic action with TRAIL, positioning azadirone as a promising candidate for cancer therapy.




**Apoptosis Induction by Neem Compounds**

**Caspase activation**

The induction of the caspase pathway regulates the apoptotic process. Nimbin (N1) and its analogue N3 demonstrated cytotoxicity against MG-63 osteosarcoma cells while remaining non-toxic to normal L6 cells (rat skeletal muscle). They effectively inhibited cell proliferation and migration, created a negative mitochondrial membrane potential, caused nuclear damage, and triggered apoptosis. Additionally, N1 and N3 induced cell cycle arrest in the G0/G1 phase, as demonstrated by flow cytometry with propidium iodide labelling. These chemicals activated the caspase cascade, resulting in the overexpression of Caspase 3 and Caspase 9. In summary, our data highlight the promise of N1 and N3 as anti-cancer medicines, indicating their potential for further research and development, either alone or in conjunction with existing medications[14].

Nimbolide had significant apoptotic effects on particular cancer cell lines, marked by elevated activity of caspase 3, 8, and 9, as well as an augmented number of apoptotic and necrotic cells. Significantly, normal cell lines exhibited no notable differences between nimbolide-treated and untreated cells, highlighting its selective effect on cancer cells. The stimulation of caspase signalling pathways was recognised as a factor contributing to nimbolide-induced apoptosis in

cancer cells. The results indicate the potential of nimbolide as a novel and attractive contender for future advancements in anticancer medication research.
Lentiviral particles targeting caspase-8 and caspase-9, along with a control shRNA, were utilised to produce caspase knockdown cells. Puromycin selection was administered to these cells, which were then subjected to neem treatment to assess caspase activity and protein expression. The results indicate a possible anticancer function of caspases in relation to neem therapy.[27].

**Extrinsic and intrinsic pathways Caspase Cascades in Apoptosis**
The terminal pathway in apoptosis can be accessed through the confluence of the extrinsic and intrinsic apoptotic pathways. The extrinsic pathway is linked to death receptor (DR)-mediated signalling, whereas the intrinsic pathway pertains to mitochondrial-mediated signalling. The extrinsic apoptotic pathway is initiated by the interaction of ligands, including TNF, Fas-L, and TRAIL, with death receptors (DRs) such as TNFR1, Fas, and TRAIL receptors. This connection creates the death-inducing signalling complex (DISC), comprising Fas-associated death domain (FADD), procaspase-8, procaspase-10, and c-FLIPs. The activation of caspase-8 within the DISC triggers a cascade that ultimately results in the execution of apoptosis. Caspases, distinguished by unique structural motifs like DED and CARD, are essential to this process. Caspase-8 and caspase-10 possess DED, whereas caspase-1, caspase-2, caspase-4, caspase-5, caspase-9, caspase-11, and caspase-12 have CARD. Initiator and effector caspases, determined by their roles in the apoptotic cascade, play a significant role in the apoptosis process.
The mitochondria predominantly facilitate the intrinsic process of apoptosis, which is activated by different stresses including oxidative stress, irradiation, and cytotoxic agents. The incorporation of Bax/Bak into the mitochondrial membrane leads to the release of cytochrome c into the cytoplasm. The anti-apoptotic proteins Bcl-2 and Bcl-xL inhibit the release of cytochrome c. The apoptosome, composed of cytochrome c, Apaf-1, and procaspase-9, activates the cascade that includes caspase-9 and caspase-3, ultimately resulting in apoptosis. Essential proteins linked to the intrinsic route are SMAC/DIABLO, Caspase-9, Bcl-2, Bcl-w, Nox, Aven, and Myc[29]. Defective mitochondria lead to a reduction in inner mitochondrial membrane potential, increased generation of superoxide ions, impairment of mitochondrial biogenesis, and the liberation of membrane proteins. These settings offer prospects for cancer therapies by promoting apoptosis in malignant cells.

**Cell cycle arrest**
Azadirachtin and nimbolide, extracted from the neem tree, demonstrated significant anti-cancer efficacy in HeLa cells. They induced cell cycle arrest, ultimately initiating apoptosis via the mitochondrial route. These chemicals elicited alterations in essential proteins, fostering a pro-apoptotic milieu. This study's findings suggest that azadirachtin and nimbolide are effective anti-cancer drugs, as they concurrently affect cell cycle progression and mitochondrial apoptosis[33].
Nimbolide, a naturally occurring chemical derived from the neem tree, exhibited significant growth inhibition in human colon cancer HT-29 cells. Treatment at concentrations between 2.5 and 10 microM resulted in significant growth suppression and induced cell cycle arrest at the G2/M phase, involving the regulation of essential cell cycle regulatory proteins. Nimbolide therapy led to an approximate 13% rise in apoptotic cells after 48 hours. These results suggest nimbolide's capacity to suppress cell proliferation and trigger apoptosis in HT-29 cells[34].
Neem leaf extract (NLE), traditionally utilised in Ayurvedic medicine for fertility management, has been shown in animal studies to trigger death in granulosa cells via the formation of reactive oxygen species (ROS). This mechanism elevates hydrogen peroxide (H2O2) concentrations, activating p53 and Bax, which subsequently affects mitochondrial membrane potential and triggers cytochrome c release. The increased cytosolic cytochrome c activates caspase-9 and caspase-3, resulting in protein degradation, DNA fragmentation, and apoptosis in follicular oocytes. In summary, NLE's activation of reactive oxygen species and mitochondria-mediated apoptosis adversely affects oocyte quality, thereby hindering reproductive success in mammals[35].

**Angiogenesis Inhibition**
Nimbolide suppresses the androgen receptor (AR) and interferes with the IGF-1/PI3K/Akt and HIF-1alpha/VEGF signalling pathways by affecting the phosphorylation and intracellular localisation of critical signalling components. It prompts epigenetic alterations marked by the downregulation of DNMT-1, HDAC-6, miR-21, HOTAIR, and H19, along with the overexpression of miR-148a/miR-152. These modifications underscore nimbolide's regulatory function in androgen receptor and IGF-1/PI3K/Akt signalling pathways. Nimbolide demonstrates increased efficacy in suppressing IGF-1/PI3K/Akt/AR signalling when coadministered with metformin and chemotherapeutic agents. The elevated expression of IGF-1R and AR in breast cancer tissues indicates their potential as indicators for progression. Neem leaf preparations exhibit anti-cancer capabilities by interfering with many signal transduction pathways, thus hindering the advancement of experimental carcinogenesis.
Neem is linked to the suppression of tumour invasion and angiogenesis. It regulates the extracellular matrix (ECM) by modulating urokinase plasminogen activator (uPA) and matrix metalloproteinases (MMPs), which are essential for tissue invasion. Neem's impact on these elements may establish conditions that either hinder or facilitate angiogenesis,

the development of new blood vessels crucial for tumour proliferation. Additional research is necessary for a thorough comprehension of neem's particular impacts on angiogenesis pathways[38].

**Modulation of Signaling Pathways**

Neem, abundant in limonoids like azadirachtin, gedunin, epoxyazadiradione, and nimbolide, demonstrates significant anticancer properties. Azadirachtin impedes cell proliferation, gedunin inhibits heat shock protein 90, epoxyazadiradione impairs tumorigenesis-related pathways, and nimbolide, the most potent neem limonoid, modulates critical kinase phosphorylation and the epigenome. These limonoids collectively combat key cancer characteristics, such as proliferation, evasion of apoptosis, inflammation, invasion, angiogenesis, and drug resistance, so positioning them as significant agents against cancer initiation and progression. The effects derived from these extracts can be attributed to cellular and molecular mechanisms, encompassing free radical scavenging, detoxification, DNA repair, modulation of the cell cycle, attenuation of programmed cell death, autophagy, immune surveillance, anti-inflammatory responses, anti-angiogenic properties, anti-metastatic activities, and regulation of diverse signalling pathways.

**Current Challenges and Future Directions**

The quinone group is considered essential for the cytocidal efficacy of various anticancer drugs, as demonstrated by Begleiter (1983) using model compounds. However, the application of quinones as anticancer medicines is limited due to their harmful side effects. The aforementioned side effects, notably Adriamycin cardiotoxicity, may be associated with the production of oxygen radicals[41].

Quinones, produced during phenol metabolism, demonstrate toxicity via direct sulfhydryl arylation and the formation of reactive oxygen species. They have mutagenic and potentially carcinogenic characteristics. Notwithstanding their hazardous characteristics, quinones, exemplified by Adriamycin and mitomycin C, demonstrate antitumor efficacy. The potential to develop selective quinones with a clearer mechanism presents opportunities for cancer therapy, potentially minimising host harm via chemoprotective agents.

Although neem possesses several medical characteristics and traditional applications, caution is advised, as some portions of the neem tree, especially in concentrated or excessive quantities, may present toxicity hazards. Neem oil, neem leaves, and other neem-derived products must be utilised cautiously, following prescribed quantities and usage instructions. Consuming significant quantities of neem oil may lead to detrimental effects. As with any herbal remedy, it is crucial to consult healthcare professionals and use caution when using neem products (42).

Antifertility effects in specific animals, including rats and mice, without disrupting spermatogenesis. This therapy in rats led to diminished fertility, a significant reduction in sperm motility, and ultimately, infertility. Significantly, it did not affect libido or cause impotence. The antifertility effect was demonstrated to be reversible within 4 to 6 weeks. In contrast, neem extract shown toxicity in guinea pigs and rabbits, leading to significant death.

The demonstrated potential for reversible male antifertility effects in certain animals, notably rats and mice, may be deemed beneficial. This research may facilitate the creation of a cost-effective, non-hormonal, readily available, and socially acceptable contraceptive alternative for women. The information presented lacks specific conclusions or outcomes of the study, leaving the details about the anti-fertility effects of Neem flower extracts ambiguous[44].

**Conclusion**

Neem contains a variety of bioactive chemicals, including limonoids (such as azadirachtin, nimbolide, and gedunin), triterpenoids (notably beta-sitosterol), and quinones. These chemicals have been thoroughly investigated for their potential anticancer activities via diverse methods, including apoptosis induction, caspase activation, cell cycle arrest, and signalling pathway regulation. Furthermore, neem has exhibited anti-inflammatory, antioxidant, and anti-angiogenic properties, all of which enhance its potential as a natural agent in cancer treatment.It is essential to recognise that although neem demonstrates potential as a source of bioactive chemicals with anticancer properties, the use of specific components, particularly in concentrated or excessive quantities, may result in harmful effects. Quinones, found in neem, are recognised for their hazardous adverse effects. Consequently, prudence is advised, and neem products should be utilised carefully, adhering to prescribed dosages and restrictions. It is also underscored that neem should be ingested in a measured manner to prevent potential adverse effects.

Neem possesses the potential for future exploration as a complementary or alternative medicine in cancer treatment. The bioactive chemicals in neem exhibit multiple methods that may suppress the proliferation of cancer cells. The deleterious effects linked to specific components underscore the necessity for cautious and informed utilisation. Additional research is required to elucidate the precise conditions and concentrations in which neem can be advantageous without inducing adverse effects, and healthcare specialists should be consulted for advice on its application.

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