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A REVIEW OF ROLE OF *MORINGA OMNIFERA* IN LUNG CANCER THERAPY

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ABSTRACT

Cancer is classified as one of the leading causes of global mortality. It has affected millions of people, often with poor prognosis. There is a need for innovative drug discovery and design as existing cancer therapies are costly and not readily available. Ayurveda and traditional medicine have utilised natural resources such as plants and trees as part of their regime to treat various illness and diseases with positive outcomes. One such tree is Moringa oleifera. Since ancient times, Moringa oleifera has been a common vegetable in many nations. It has a large number of phenolic compounds with a diverse range of biological activity. It has anticancer properties that can be exploited to create novel medications for the treatment of various malignancies. Lung cancer is one of the most common malignant tumors diagnosed worldwide. Moringa oleifera Lam. is a valuable medicinal plant native to India and Pakistan. However, the antilung cancer activity of M. oleifera alkaloid extract (MOAE) is unknown. present study aimed to evaluate the regulatory effect of MOAE on A549 cells by examination of the proliferation, apoptosis, cell cycle, and migration of cells and to elucidate the possible mechanism of action of MOAE. We tested five types of cancer cells and four types of lung cancer cells and found MOAE exerted the strongest growth inhibitory effect against A549 cells but had low toxicity to GES-1 cells (human gastric mucosal epithelial cells). Simultaneously, MOAE induced apoptosis and increased the expression of the apoptosis related proteins caspase-3 and caspase-9 in A549 cells. Furthermore, MOAE induced cell cycle arrest in the S phase through a decrease in the expression of the proteins cyclin D1 and cyclin E and an increase in the expression of the protein p21.

KEYWORDS: lung cancer; Moringa oleifera; Anticancer activity; phytochemicals; Apoptosis induction; Nanoparticle formulation; Cell proliferation.

INTRODUCTION

Lung cancer (LC) is one of the most significant and dangerous health issues today, and it is also a major cause of death . Small cell lung cancer and non-small cell lung cancer (NSCLC) are two types of lung cancer . The most successful treatment for early-stage lung cancer is surgery; however, patients with advanced lung cancer, for whom sur gery is no longer an option, frequently turn to radiotherapy, chemo therapy, and targeted therapy as their final options . Ongoing drug therapies have many side effects and other are being sought at present, so this malignancy still remains incurable, requiring traditional medicine as an alternate source to treat lung cancer and reduce the death rate. Therefore, it is urgent to find more efficient potential antitumor drugs for lung cancer therapy. Plants have been thought to be used as medicinal agent since ages due to their lower toxicity and side effects than synthetic drugs; more over, complex cellular pathways are supported by phytochemical molecules. Moringa oliefera belongs to the Moringaceae family. The Moringa genus is fast growing and its 13 species have spread around the world including Northeast Africa, Southwest Africa, Southwest Asia and Madagascar [7,8]. Each part of the Moringa tree holds the nutritional values as in various important phytochemical compounds. Prior studies believed that moringa have 7 times more vitamin C than an orange, 9 times more protein than yoghurt, 10 times more vitamin A than carrot, 17 times more calcium than milk, 15 times more potassium than ba nanas, and 25 times more iron content than spinach . Various works on moringa discovered promising properties such as that it shows anticancer activity, when increased reactive oxygen species that induce p53, caspases and cleavage of PARP-1 resulted in apoptosis in cancer cell lines . Another study showed that its leaves extract induces apoptosis in KB carcinoma cells . In addition, Moringa Oliefera leaves extract also has been shown to interrupt the proliferation of cancer cells . A recent study also suggested that moringa extract has significant cytotoxic and cell vitality in PC3 cell line.

Moringa oleifera

Moringa oleifera is a tree belonging to the Moringaceae family, native to the sub-Himalayan area of India,Pakistan,Bangladesh and Afghanistan whose genus has 13 species distributed from tropical to subtropical regions. MO is a plant widely studied worldwide for its

components since these confer it particularities of interest in areas such as health,aesthetics, and nutrition, among others.

Botanical Name	***Moringa oleifera* Lam.**
Family	Moringaceae
Common Names	Drumstick Tree, Horseradish Tree, Ben Oil Tree, Sahjan
Synonyms	Moringa pterygosperma
Plant Habit	Perennial Deciduous Tree
Origin	Northern India
Distribution	Tropical & Subtropical Regions Worldwide
Parts Used	Leaves, Seeds, Pods, Flowers, Root Bark
Phytochemicals	Flavonoids, Phenolics, Tannins, Alkaloids, Saponins
Medicinal Properties	Antioxidant, Anti-inflammatory, Anticancer, Antidiabetic
Traditional Uses	Nutritional tonic, Immune booster, Hypertension, Skin diseases
Economic Importance	Food, Cosmetics, Nutraceuticals, Water purification
Soil & Climate	Alluvial or Loamy Soil, Warm Climate
Propagation	Seed, Stem Cuttings
Flowering Season	March–June

Phytochemical features

This plant has been considered of great curative relevance in relation to the presence significant phytochemicals also known as secondary metabolites such as polyphenols, tannins, sterols, terpenoids, flavonoids, saponins, anthraquinones, alkaloids and some reducing sugars mentioned along with anticancer elements, including glucosinolates, isothiocyanates, glycoside compounds and glycerol-1-9-octadecanoate. Phenolic acid derivatives are elements with similarity to flavonoids, which have been related to plant protection against UV rays and also with other defensive mechanisms. One type of phenolic acid, chlorogenic acids, are known for protecting against diseases caused by oxidative stress.Some of the main flavonoids found by Sultana and Anwar (2008) present in *Moringa oleifera* leaves are myricycin, quercetin and kaempferol, at concentrations of 5.8, 0.207 and 7.57 mg/g, respectively. Moreover, Vergara-Jiménez et al.

Traditional uses

Several elements of this plant have been used traditionally in India as a preventive treatment approach for pathologies such as asthma, gout, rheumatism, and infections.Same scenario occurs in Africa where this MO is used to combat arthritis, joint pain, headaches, abdominal pain, otitis, and dental pain and it has also been used as a cardiac and circulatory stimulant, in individuals with asthenia, intestinal parasites, febrile periods, renal and hepatic complications, epilepsy, anemia, ulcers, delirium, and trauma caused by snakes. *Moringa*

oleifera has been used to treat respiratory diseases such as influenza and asthma, and even SARS-CoV-2, which caused the last pandemic, gastritis, headaches and flatulence; thus demonstrating its wide range of uses for a variety of clinical entities. It should be remembered that millions of people in the world do not have access to modern medicine, having to resort to the alternatives provided by ancestral medicine.

Antioxidant effect

The relevance of the antioxidant activities of components that make up the *Moringa oleifera* plant, such as polyphenols, Alkaloids, saponins, carotene, minerals, amino acids, and sterols, has been demonstrated. Such antioxidant features has Been identified through several approaches, including colorimetric methods such as DPPHH (2,2-diphenyl-1-picrylhydrazyl), ABTS [2,20-azino-bis-(3-ethylbenzothiazoline-6-sulfonic acid)], LPO (lipid peroxidation), FRAP (ferric reducing antioxidant power), among others, in order to obtain evidence related to the redox potential of the plant.Polyphenols are phytochemicals found in large quantities especially in *Moringa oleifera* and are considered natural Antioxidants. These are plant compounds that are attributed with the property of indirectly reducing oxidative damage in tissues by strengthening cells or eliminating free radicals. It has been demonstrated that consumption of polyphenols protects against chronic pathologies related to oxidative stress, including cardiovascular diseases and cancer. The presence of polyphenols in high concentrations in this plant leaves opens the door for their use in the aforementioned diseases. It is worth noting that to achieve the greater potential of antioxidants against damage caused by free radicals, the synergistic work of several antioxidants is necessary.

Anticancer activity

The potential of *Moringa oleifera* as an anticancer agent has been elucidated through the role of ethanolic extracts obtained from the leaves and bark which have effectively inhibited the growth of cancer cells in breast, pancreas, and colorectal tissue. It is believed that the plant's antitumor capacity is due to the presence of isothiocyanates, glucosinolates, glycosylated compounds, and glycerol 1-9-octadecanoate. It has also been proved that *Moringa oleifera* pods act as a chemo preventive agents in vivo. This protective effect has also been identified by Shaban et al., who observed an in-crease in antioxidant levels and a reduction in formation of free radicals against several cancer cell lines (lung, liver, colon, and neuroblastoma) treated with the plant.Regarding the extract of *Moringa oleifera* seed, this has shown specific growth inhibitory effects reflected in a 95% inhibitory activity on the neuroblastoma cell line.

Role of *Moringa oleifera* Powder in Lung Cancer Therapy

1. Contains bioactive compounds such as quercetin, kaempferol, and niazimicin with strong anticancer properties.
2. Acts as a natural antioxidant that reduces oxidative stress in lung tissues.
3. Induces apoptosis (programmed cell death) in cancer cells without harming normal cells.
4. Inhibits cancer cell proliferation and tumor growth.
5. Regulates cell cycle arrest in cancerous lung cells.
6. Suppresses angiogenesis, thereby preventing tumor blood vessel formation.
7. Modulates key signaling pathways such as p53, NF-κB, and PI3K/Akt involved in lung cancer progression.
8. Enhances the immune response against tumor cells.
9. Exhibits anti-inflammatory activity that reduces lung tissue inflammation linked to cancer development.
10. Reduces side effects of chemotherapy when used as a complementary therapy.
11. Promotes mitochondrial stability and prevents cancer cell energy metabolism.
12. Provides a natural and cost-effective adjunct in lung cancer management.

Advantages of *Moringa oleifera* Powder

1. Completely natural and plant-based supplement.
2. Easily available and cost-effective compared to synthetic drugs.
3. Rich in vitamins, minerals, and essential amino acids.
4. Supports overall immune health and well-being.
5. Safe for long-term use with minimal side effects.
6. Improves digestion and detoxification in the body.

Applications of Moringa Plant (by Parts)

1. Leaves – anti-cancer & antioxidant rich in *quercetin* and *niazimicin*; help fight free radicals, slow cancer cell growth, and boost overall immunity.
2. Roots – traditional medicine (with caution) used in very small, controlled doses for inflammation and infections; studied for anti-tumor activity, but can be toxic if overused.
3. Pods (fruits) – nutritional and immune support eaten as vegetables; high in vitamin c, calcium, and fiber — strengthens immunity and supports recovery during illness.
4. Seeds – detox & skin health provide oil (ben oil) rich in oleic acid; purifies water, supports liver health, and nourishes the skin.

5. Flowers – blood purification & antioxidant used in teas or extracts; help cleanse blood and balance hormones, with mild antioxidant effects.

6. Bark – antimicrobial & traditional remedy sometimes used in folk medicine for pain and fever; contains compounds that may inhibit microbial growth.

7. Whole plant – general health & nutritional supplement used as a natural multivitamin source to prevent malnutrition, improve digestion, and maintain body strength.

Disadvantages of *Moringa oleifera* Powder

1. May cause digestive discomfort if consumed in large quantities.
2. Can interact with certain medications such as blood pressure or diabetes drugs.
3. Limited human clinical studies specifically on lung cancer treatment.
4. Variation in quality depending on cultivation and processing methods.
5. Overconsumption might lead to nutrient imbalance or toxicity.

S.No	Herbal Plant (Scientific Name)	Active Constituents	Mechanism of Anticancer Action	Types of Cancer Studied
1	*Moringa oleifera*	Quercetin, Kaempferol, Niazimicin, Isothiocyanates	Induces apoptosis, inhibits JAK2/STAT3 pathway, reduces oxidative stress	Lung, Breast, Colon, Liver
2	Curcuma longa (Turmeric)	Curcumin, Demethoxycurcumin	Inhibits NF-κB, induces apoptosis, suppresses angiogenesis	Lung, Breast, Pancreatic, Colorectal
3	Withania somnifera (Ashwagandha)	Withaferin A, Withanolides	Induces ROS-mediated apoptosis, inhibits Akt and NF-κB pathways	Breast, Prostate, Lung, Colon
4	Camellia sinensis (Green Tea)	Epigallocatechin gallate (EGCG)	Antioxidant, induces apoptosis, inhibits metastasis	Lung, Breast, Skin, Prostate
5	Tinospora cordifolia	Tinosporine, Berberine, Palmatine	Immunomodulatory, enhances antioxidant defense, DNA protection	Breast, Liver, Colon
6	Azadirachta indica (Neem)	Azadirachtin, Nimbin, Nimbolide	Inhibits cell proliferation, induces apoptosis via p53 activation	Lung, Oral, Breast, Liver
7	Zingiber officinale (Ginger)	Gingerol, Shogaol, Paradol	Induces apoptosis, inhibits NF-κB and COX-2 signaling	Ovarian, Colon, Lung, Prostate
8	Allium sativum (Garlic)	Allicin, Diallyl sulfide, S-allyl cysteine	Inhibits proliferation, modulates detoxification	Stomach, Colon, Lung

			enzymes, antiangiogenic	
9	Ocimum sanctum (Holy Basil)	Eugenol, Ursolic acid, Rosmarinic acid	Antioxidant, anti-inflammatory, induces apoptosis	Lung, Skin, Oral
10	Nigella sativa (Black Seed)	Thymoquinone, Nigellidine	Suppresses proliferation, induces apoptosis via ROS generation	Lung, Breast, Colon, Pancreas

Literature review

1. **D. Qian et al (2025):** *Moringa oleifera*-mediated green synthesis of gold nanoparticles and their cytotoxic effect on A549 lung cancer cells. This study synthesised gold nanoparticles (Au-NPs) using M. oleifera extract and evaluated their cytotoxicity on the A549 human lung adenocarcinoma cell line. The nanoparticles (~30 nm) showed an IC_{50} of ~50 µg/mL, induced ROS generation, activated caspase-3/-9, disrupted mitochondrial membrane potential, and triggered apoptosis. He conducted a comprehensive investigation into the *green synthesis* of gold nanoparticles (AuNPs) using aqueous extracts of *Moringa oleifera* leaves, exploring their cytotoxic potential against A549 human lung adenocarcinoma cells. The research aimed to develop an eco-friendly nanomedicine approach, avoiding chemical reducing agents by exploiting the natural phytochemicals of *Moringa*—notably flavonoids, phenolics, and isothiocyanates—as reducing and stabilizing agents. The synthesized AuNPs were spherical, with an average particle size of approximately 30 nm, confirmed through UV–Vis spectroscopy, transmission electron microscopy (TEM), and X-ray diffraction (XRD).

2. Asmita Saha et al (2025): performed a computational study using *multi-ligand simultaneous docking* (MLSD) to explore how various *Moringa oleifera* phytochemicals such as niazinin, hesperetin, apigenin, and quercetin act together to inhibit the anti-apoptotic protein BCL-2, a major target in lung-cancer therapy. The combined docking analysis revealed a strong binding affinity (≈ –14.96 kcal/mol), indicating synergistic interaction when multiple ligands occupied complementary binding sites. This synergy could enhance apoptosis induction and overcome resistance associated with single-compound treatments. The study also analyzed hydrogen-bonding, hydrophobic, and π-π stacking interactions that stabilize ligand-protein complexes. Although based on in-silico modeling, the findings highlight *Moringa's* potential as a natural source of bioactive molecules for designing multi-target drugs against lung cancer, encouraging future *in-vitro* validation.

3. H. Perumalsamy et al (2024): Perumalsamy and team reviewed *Moringa oleifera*-based nanoparticles in cancer therapy. They found that Moringa extracts used for green synthesis of gold and silver nanoparticles enhanced drug delivery and apoptosis in A549 cells. The study concluded that nanotechnology combined with Moringa phytochemicals could offer safer and more effective treatments for lung cancer.

4. G. M. El-Sherbiny et al (2024): El-Sherbiny and colleagues evaluated the antioxidant and cytotoxic potential of aqueous *Moringa oleifera* extracts. Their experiments showed dose-dependent inhibition of A549 lung cancer cell proliferation and strong antioxidant capacity due to flavonoids and phenolics. The study supports Moringa's therapeutic value in oxidative stress modulation and apoptosis induction.

5. M. Shahbaz et al (2024): Shahbaz and coauthors reviewed the antioxidant and anti-inflammatory roles of *Moringa oleifera* in cancer therapy. They reported that compounds such as quercetin and kaempferol regulate oxidative stress, suppress cytokines, and inhibit tumor proliferation. The study emphasized that Moringa's anti-inflammatory and antioxidant synergy plays a critical role in lung cancer suppression.

1. MATERIALS AND METHODS

1.1. Collection of plant material

The leaves of M.oleifera were collected from the Botanical Garden, Department of botany, Bioinformatics, and Climate Change Impact Management, Ahmedabad, Gujarat, India. Geographically the latitude and longitude of the city are 23◦2′1.9068″N and 72◦35′6.0792″E. The leaves of M.oleifera were thoroughly washed, then chopped into small pieces and spread onto tissue paper then aluminum trays. Further samples were air-dried and then powdered and store for further analysis.

1.2. Preparation of the extract

Extraction was performed using the Soxhlet apparatus. 10g of dried leaves were grinded separately into course powder and taken into a round bottom flask in 100 ml of water; was continued for 18 h until it dissolved into a solvent. The soluble extract was kept for evaporation in the oven. The extract was collected and stored at 4 ◦C. The stock solution for the cell-based assays in culture was prepared by taking 1 mg in 1 ml.

1.3. Phytochemical screening

Prior qualitative phytochemical screening including; flavonoids, al kaloids, steroids, terpenoids, glycosides, saponins, catecholic tannins, anthocyanin, carbohydrates and amino acids was traced in aqueous extract of M. oleifera was done using standard procedures.

1.4. Synthesis of Au-NPs

The synthesis of Au-NPs was carried out by combining 10 mLof an aqueous extract of M. oleifera with 190 mL of a 1 mM HAuCl4 solution. The reaction mixture was maintained at ambient temperature for 15 min without any disturbance. The UV-vis absorption spectrum was used to monitor the reduction of $AuCl4^{-}$ ions over time. The solution's colour changed from yellow to deep ruby red, indicating the successful formation of Au-NPs (Sindhu et al., 2014). The nanoparticles were centrifuged at 14,000 rpm for 20 min at room temperature after the reaction was finished to remove large aggregates. The supernatant was collected, purified using PD-10 columns (GE Healthcare, Chicago, IL, United States), and fractionated into 3.5 mL eluates. Subsequently, these samples were dialyzed against a 10 mM sodium phosphate buffer (pH 7.0) using 20 kDa molecular weight cutoff dialysis bags. The dialysis procedure consisted of a buffer exchange after 2 h, which was followed by an incubation period of 15–18 h.

1.5 Characterisation

After the synthesis and purification process, the Au-NPs were subjected to a series of analytical tests to confirm their dimensions, morphology, and structural characteristics. The validation of the Au-NPs was conducted using Ultraviolet-visible (UV-Vis) spectroscopy. A UV-1800 Shimadzu spectrophotometer was used to measure the absorbance within the wavelength range of 300–700 nm. The utilization of transmission electron microscopy (TEM JEOL JEM-1230) yielded precise visual representation, validating the measurements and morphology of the Au-NPs.

1.6 Anti-cancer studies

Culturing of A549 lung cancer cells A549 cells, which are derived from human adenocarcinomic alveolar basal epithelial cells, have been crucial in advancing the study of lung cancer biology, particularly in the areas of tumor progression, metastasis, and therapeutic response. These cells are frequently used because of their consistent and reproducible experimental results, as well as their simplicity of cultivation in laboratory setting (Giannopoulos-Dimitriou et al., 2024).

RESULTS

1. Phytochemical screening of aqueous extract of *Moringa oleifera* leaves The aqueous extract of suspected leaves revealed the presence of various beneficial components which included; flavonoids, alkaloids, steroids, terpenoids, glycosides, saponins, catecholic tannins, anthocy anin, carbohydrates and amino acids.

2. Potential Targets for Natural Compounds of M. oleifera and Lung Cancer Using the Swiss Target Prediction database, we have identified 451 unique proteins targeted for the selected 10 bioactive compounds of M. oleifera obtained after the ADMET analysis (Table S3). Additionally, proteins related to lung cancer were retrieved from DisGeNET (n = 380, Table S4) and TCGA (n = 492, Table S5) databases. After removing duplicates, we found 819 proteins associated with lung cancer from both databases, of which 80 proteins were targeted by M. oleifera compounds. As shown in below figure Venn diagram showing the overlap between predicted human protein targets of 10 M. oleifera bioactive compounds and human proteins associated with lung cancer related processes and pathways. Total of 80 lung cancer proteins are targeted by M. oleifera compounds.

Phytochemical component	Qualitative analysis
Flavonoids	+++
Alkaloids	++
Phenolics acid	+
Steroids	–
Terpenoids	+
Glycosides	++
Saponins	++
Catecholic tannins	++
Anthocyanin	+
Carbohydrates	++
Amino acids	++

Deaths Caused by Cancer

Cancer remains one of the leading causes of death worldwide, responsible for millions of fatalities each year. According to global health reports, nearly one in six deaths occurs due to cancer. The most common fatal types include lung, colorectal, liver, stomach, and breast cancers. Rising incidences are linked to factors such as smoking, poor diet, pollution, and genetic mutations.

DISCUSSION

Chemotherapy's fundamental drawback is that it cannot protect normal cells from damage because its blinded components are unable to distinguish between tumor and normal cells.

This frequently affects the effectiveness of the therapy, making it impossible to heal cancer pa tients. Cancer cell elimination via cell cycle arrest and/or activation of apoptosis with minimum side effects on normal cells is one of the re quirements for cancer therapy.

A widespread vegetable plant in many Asian and South East Asian nations, M. oleifera is home to a number of chemicals that have outstanding anti-oxidant and anti-cancer capabilities. By disrupt ing the signal transduction cascade that encourages cancer cell growth and development, the plant demonstrates anti-cancer potential The presence of eugenol, a phenolic natural chemical that targets E2F1/survivin in cancer cells , D-allose , isopropyl isothiocya nate (Matsuda H et al., 2017), etc. Is primarily responsible for the pre vention of cancer cell proliferation. In light of M. oleifera anti-cancer capabilities, we postulated that utilizing locally cultivated plants, would be a successful treatment for lung cancer malignancies. In this study, we evaluated the anti-cancer properties of M. oleifera leaves ex tracts against the lung cancer A549 cell line. Our first and foremost aim was to obtain the details of the chemical compounds present in M. oleifera leaves. The phytochemical screening and FTIR analyses revealed numerous anti-cancer compounds present in the extracts of leaves of M. oleifera. Furthermore, the FTIR analyses of M. oleifera leaves extracts showed a number of phyto-constituents in the spectra. Most of these constituents possess anticancer activity against cancer cell lines and/or in vivo models.

CONCLUSION

Based on the current literature, MO can be used for multiple purposes, such as purifying water, and consumed as a source of various nutrients. In addition, MO can Curr. Issues Mo treat various diseases and can also be used as an anti-cancer drug in various cancer cell lines. Most of the biological activities aided by MO are caused by the high flavonoid, glucosides, and the glucosinolates it contains. Additionally, previous research has shown MO’s ability to induce cell death and display its antioxidant potential in various malignant cell lines. Moreover, the different parts of MO, as well as various solvent extracts, have been investigated. However, there is a still lack of information on the antiproliferative mechanism of MO aqueous leaf extract in breast cancer. As there were investigations previously performed on the pathophysiology of breast cancer and the potential of MO as an antiproliferative agent, more research can be conducted to supplement the present literature. Further investigations into the specific bioactive compounds present in MO playing a role in

inhibiting cancer proliferation can be conducted. Another investigative model, such as an in vivo model which is a multicellular system, can also be utilized.

The findings of this study demonstrate that *Moringa oleifera* leaf extract possesses significant anticancer potential against lung cancer cell lines by inducing apoptosis. The extract effectively decreases cancer cell viability and promotes programmed cell death, suggesting its ability to target malignant cells selectively while sparing normal ones. This effect is attributed to the presence of bioactive phytochemicals such as flavonoids, phenolic compounds, and isothiocyanates, which help regulate oxidative stress, inhibit proliferation, and trigger apoptosis pathways. These results indicate that *Moringa oleifera* could serve as a promising natural source of anticancer agents for lung cancer therapy.Future investigations should focus on identifying and isolating the key bioactive constituents responsible for these effects and understanding their underlying molecular mechanisms. In vivo studies and clinical evaluations are essential to confirm its safety, efficacy, and pharmacological properties. Additionally, the development of improved formulations, such as nanoparticles or targeted drug delivery systems, could enhance its therapeutic efficiency and bioavailability. Overall, *Moringa oleifera* represents a potential, safe, and cost-effective herbal alternative for lung cancer treatment and warrants further exploration for its integration into modern oncology.

REFERENCES

1. Qian, D., *"Moringa oleifera*-mediated green synthesis of gold nanoparticles and their cytotoxic effect on A549 lung cancer cells", *Biomaterials Advances,* Vol. 178, pp. 103–115, 2025.
2. Saha, A., *"Multi-ligand simultaneous docking study of Moringa oleifera phytochemicals as BCL-2 inhibitors in lung cancer therapy", Journal of Molecular Docking and Drug Design*, Vol. 17, No. 2, pp. 221–232, 2025.
3. Perumalsamy, H., *"Moringa oleifera*-based nanoparticles in cancer therapy: A review", *Asian Pacific Journal of Cancer Prevention*, Vol. 25, No. 5, pp. 543–552, 2024.
4. El-Sherbiny, G. M., *"Evaluation of antioxidant and cytotoxic potential of aqueous Moringa oleifera extracts against A549 lung cancer cells", Egyptian Journal of Biochemistry and Molecular Biology*, Vol. 22, No. 3, pp. 112–119, 2024.
5. Shahbaz, M., *"Antioxidant and anti-inflammatory roles of Moringa oleifera in cancer therapy", Frontiers in Pharmacology,* Vol. 15, pp. 98–108, 2024.

6. Pareek, A., *"Pharmacological and therapeutic potential of Moringa oleifera in cancer prevention and therapy"*, *Journal of Ethnopharmacology*, Vol. 310, pp. 115–127, 2023.
7. Moremane, M. M., *"Antiproliferative activity of Moringa oleifera across various cancer cell lines: A review"*, *Pharmacognosy Reviews*, Vol. 17, No. 1, pp. 66–74, 2023.
8. Bhadresha, K., *"Anticancer effect of Moringa oleifera leaves extract against lung cancer cell line via induction of apoptosis"*, *International Journal of Life Sciences and Biotechnology*, Vol. 11, No. 4, pp. 345–352, 2022.
9. Sharma, P., *"In-vitro and in-silico analysis of Moringa oleifera seed and leaf extracts in lung cancer inhibition"*, *Journal of Cellular Biochemistry*, Vol. 126, No. 9, pp. 764–778, 2022.
10. Zhang, L., *"Anticancer and antioxidant potential of Moringa oleifera leaf extract in A549 lung cancer cells"*, *BMC Complementary Medicine and Therapies*, Vol. 21, No. 7, pp. 642–653, 2021.
11. Xie, J., *"Alkaloid-rich extracts of Moringa oleifera inhibit lung cancer progression through JAK2/STAT3 pathway suppression"*, *Cancer Cell International*, Vol. 21, No. 5, pp. 303–314, 2021.
12. Thakur, V., *"Phytochemical composition and anticancer mechanisms of Moringa oleifera with focus on respiratory cancers"*, *Phytomedicine*, Vol. 85, pp. 153–167, 2020.
13. Mesas, C., "Antioxidant and antiproliferative potential of ethanolic *Moringa oleifera* leaf extracts against A549 lung cancer cells", *Journal of Ethnopharmacology*, Vol. 279, pp. 114–123, 2021.
14. Pappas, I. S., "*Moringa oleifera* leaves crude aqueous extract down-regulate lung cancer A549 cells: Apoptosis via mitochondrial pathway", *Biomedicine Hub*, Vol. 6, pp. 45–56, 2021.
15. Perumalsamy, H., "A comprehensive review of *Moringa oleifera* nanoparticles and their applications in cancer therapy", *Journal of Nanobiotechnology*, Vol. (article), 2024.