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A comprehensive review on the therapeutic applications and recent trends of *Arachis hypogaea* Leaves: An Exploration

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Abstract
This comprehensive review delves into the therapeutic potential and recent trends concerning the leaves of *Arachis hypogaea*, commonly known as peanut. While peanuts are primarily recognized for their nutritional value, this review highlights the significant therapeutic potential of their leaves, presenting a well-rounded exploration of their applications in modern medicine. Traditionally overshadowed by the nutritional value of its seeds, the leaves of *Arachis hypogaea* possess a rich array of bioactive compounds with significant medicinal properties. This review synthesizes current research, highlighting the anti-inflammatory, antioxidant, antimicrobial, and anticancer activities attributed to these bioactive constituents. By exploring the mechanisms underlying these therapeutic effects, the review provides a detailed analysis of both preclinical and limited clinical studies. Additionally, it addresses recent advancements and future research directions, emphasizing the need for further clinical trials to substantiate the medicinal benefits of peanut leaves. The safety profiles and potential toxicity are also discussed to present a balanced perspective. This exploration aims to elevate the recognition of *Arachis hypogaea* leaves in the realm of natural therapeutics, therapeutic applications, and recent trends in the herbs with encourage further scientific inquiry into their health-promoting potential.

Keywords: Therapeutic effects, *Arachia hypgaea*, antibacterial, leaf extract, herbal formulations, advance trends, phytoconstituents application, medical plants, herbs

Introduction
In Ayurveda, the traditional medical system of India dating back over 3,000 years, herbs such as turmeric, ashwagandha, and neem have been integral. Turmeric is renowned for its anti-inflammatory and antioxidant properties, ashwagandha for its adaptogenic qualities, and neem for its antimicrobial and skin-healing benefits. The Greeks and Romans also relied heavily on herbal medicine [1-2]. Hippocrates, often referred to as the father of medicine, and Dioscorides, a Greek physician and pharmacologist, documented numerous herbs in their medical texts. Herbs like rosemary, mint, and fennel were used for their digestive and medicinal properties. Dioscorides' "De Materia Medica" was a comprehensive guide to herbal medicine used for centuries. In Indigenous cultures across the Americas, herbs played a critical role in healthcare. Native American tribes utilized plants such as echinacea for immune support, willow bark as a natural pain reliever (which contains salicin, a precursor to aspirin), and various other plants for their healing properties in treating wounds, infections, and chronic conditions [2-4].
Herbal extracts play a vital role in both traditional and modern therapeutic applications due to their rich composition of bioactive compounds. *Arachis hypogaea*, commonly known as peanut, is primarily celebrated for its seeds, which are a rich source of nutrients and oils. However, the leaves of *Arachis hypogaea* have remained relatively underexplored despite their potential therapeutic benefits. Historically, the use of plants for medicinal purposes has been well-documented, with numerous plant species recognized for their therapeutic properties [5]. In this context, the leaves of *Arachis hypogaea* present a promising, yet underutilized, natural resource. Preliminary studies have identified various bioactive constituents in these leaves, including flavonoids, tannins, saponins, and other phenolic compounds, which contribute to their pharmacological activities. As the demand for natural and plant-based therapies grows, there is a compelling need to explore and validate the medicinal potential of underutilized plant parts such as peanut leaves [4-8]. The *Arachis hypogaea* widely utilized in the several therapeutic applications such as per the given Fig. 1 below followings.

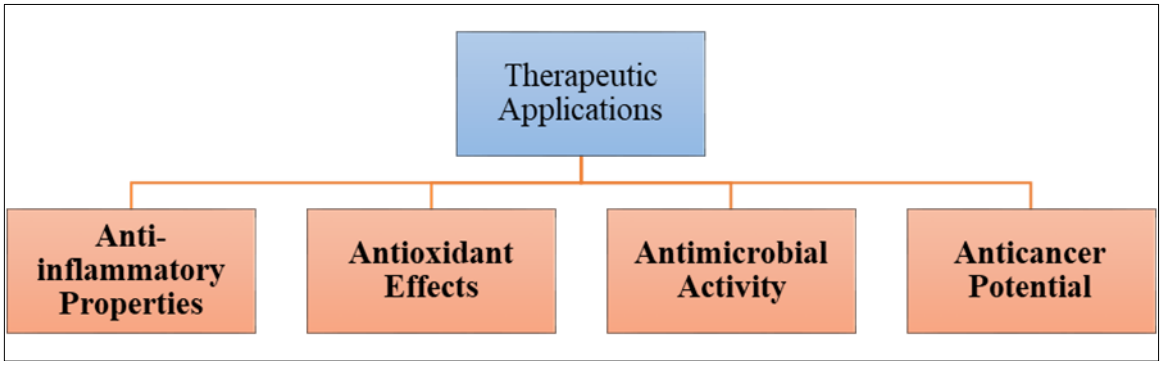

Fig 1: The different therapeutic applications of *Arachis hypogaea*

These compounds contribute to a wide array of medicinal properties. Anti-inflammatory properties of peanut leaves have been demonstrated in various studies, suggesting their potential in managing inflammatory conditions like arthritis. The antioxidant capacity of the leaves, attributed to their high phenolic content, helps in combating oxidative stress, thereby offering protective effects against chronic diseases such as cardiovascular diseases and neurodegenerative disorders [9]. Additionally, the antimicrobial activity of *Arachis hypogaea* leaves has shown effectiveness against a range of pathogens, making them useful in treating infections. Emerging research also highlights the anticancer potential of these leaves, with certain compounds exhibiting the ability to inhibit cancer cell growth and induce apoptosis. Collectively, these therapeutic applications underscore the importance of further exploring the medicinal benefits of *Arachis hypogaea* leaves, which could pave the way for new, natural treatment options in modern medicine [10-12].

The objective of this review is to provide a comprehensive overview of the therapeutic applications and recent trends in the study of *Arachis hypogaea* leaves. By synthesizing existing research, this review seeks to elucidate the mechanisms by which these bioactive compounds exert their effects, explore the range of their medicinal properties, and highlight recent advancements in this field. Furthermore, the review will discuss the challenges and limitations in current research and propose directions for future studies to fully realize the potential of *Arachis hypogaea* leaves in modern therapeutics.

2. botanical overview of *Arachis hypogaea*

Taxonomy and Morphology: *Arachis hypogaea*, commonly known as peanut or groundnut, belongs to the family *Fabaceae (Leguminosae)*. It is a species in the genus Arachis, which encompasses approximately 80 species, including both wild and cultivated varieties of peanuts. The plant is an annual herbaceous legume that grows upright or as a trailing vine, with a height ranging from 30 to 50 centimeters [13-15]. The morphological description about *Arachis hypogaea* mentioned in the Table 1 as follows.

Table 1: The biological description of sources *Arachis hypogaea* (peanut) [12-17]

Attribute	Description
Scientific Name	*Arachis hypogaea*
Common Names	Peanut (Mungfali), Groundnut
Family	*Fabaceae (Leguminosae)*
Genus	Arachis
Species	A. hypogaea
Origin	South America (particularly Bolivia and Argentina)
Growth Habit	Annual herbaceous plant
Height	30 to 50 centimeters
Stems	Slender, pubescent, branching near the base
Leaves	Pinnately compound, 2-4 pairs of leaflets
Leaflet Shape	Elliptical to ovate
Leaf Arrangement	Alternate
Flowers	Axillary inflorescences, papilionaceous, yellow
Fruit Type	Pod (develops underground)
Seed Count per Pod	1 to 4 seeds (peanuts)
Root System	Taproot with lateral branches
Soil Preference	Well-drained sandy loam
Climate Requirement	Tropical, subtropical, warm temperate
Economic Uses	Food (peanuts), oil extraction, animal feed

Stems and Leaves: The stems of *Arachis hypogaea* are slender and pubescent, with branching occurring near the base. The leaves are pinnately compound, consisting of two to four pairs of leaflets and a terminal leaflet. Each leaflet is elliptical to ovate in shape, with a smooth margin and a slightly pointed apex. The leaves are typically green in color, and their arrangement is alternate along the stems [18-19].

Flowers and Fruits: The flowers of *Arachis hypogaea* are borne on axillary inflorescences, emerging from the leaf axils. They are papilionaceous, with a typical legume flower structure, featuring a banner petal, two wing petals, and two fused keel petals. The flowers are usually yellow in color with varying degrees of red or purple markings. After pollination, the flowers give rise to peg-like structures that penetrate the soil, where the fruits (peanuts) develop underground. Each fruit contains one to four seeds, commonly referred to as peanuts or groundnuts [20]. The different phytoconstituents of

Arachis hypogaea discussed in the given Table 2 as below followings.

Table 2: The phytoconstituents and phytochemical parameters typically found in *Arachis hypogaea* (peanut) [18-22]

Phytoconstituents	Phytochemical Parameters
Flavonoids	Quercetin, Kaempferol
Phenolic acids	Caffeic acid, Gallic acid
Tannins	Ellagic acid, Catechins
Saponins	Arachidins, Soyasaponins
Phytosterols	Beta-sitosterol, Stigmasterol
Fatty acids	Oleic acid, Linoleic acid
Vitamins	Niacin (B3), Folate (B9)
Minerals	Potassium, Magnesium
Protein	Essential amino acids
Carotenoids	Beta-carotene, Lutein
Antioxidants	Vitamin E, Resveratrol
Alkaloids	Trigonelline, Caffeine
Enzymes	Protease, Lipase
Polysaccharides	Arabinogalactan, Xylan
Phytohormones	Gibberellins, Cytokinins
Polyphenols	Resveratrol, Curcumin

This table provides the diverse range of phytoconstituents and phytochemical parameters that contribute to the nutritional and medicinal properties of *Arachis hypogaea*.

Geographic Distribution and Cultivation: *Arachis hypogaea* is native to South America, particularly regions of Bolivia and Argentina. However, it is now cultivated globally in tropical, subtropical, and warm temperate regions. Peanuts require well-drained sandy loam soil with good moisture retention and a warm climate for optimal growth [23-24]. They are an important crop for food, oil extraction, and animal feed, contributing significantly to agricultural economies worldwide.

Economic Importance: *Arachis hypogaea* is a commercially important crop due to its nutritional value and versatile uses. The seeds (peanuts) are rich in protein, fats, vitamins (especially niacin and folate), and minerals (such as potassium and magnesium), making them a valuable dietary staple. Peanut oil extracted from the seeds is widely used in cooking and food processing. Additionally, peanuts are utilized in confectionery, snack foods, and as an ingredient in various culinary preparations [25].

3. phytochemical composition of *Arachis hypogaea* leaves

3.1 Overview of Bioactive Compounds: The leaves of *Arachis hypogaea* (peanut) are rich in various bioactive compounds that contribute to their potential therapeutic applications. These compounds include flavonoids, phenolic acids, tannins, saponins, phytosterols, fatty acids, vitamins, minerals, proteins, carotenoids, alkaloids, enzymes, polysaccharides, phytohormones, and polyphenols. The each category of compounds plays a unique role in the pharmacological properties of peanut leaves. The leaves of *Arachis hypogaea* (peanut) are rich in various bioactive compounds that contribute to their medicinal properties [24-27]. The below Table 3 discussed the phytochemicals present in peanut leaves especially as following.

Table 3: The list of phytochemical categories, their key compounds and included the functions [23-26]

Phytochemical Category	Key Compounds	Properties/Functions
Flavonoids	Quercetin, Kaempferol, Myricetin	Antioxidant, anti-inflammatory, anticancer
Phenolic Acids	Caffeic acid, Gallic acid, Ferulic acid	Antioxidant, antimicrobial, anti-inflammatory
Tannins	Ellagic acid, Catechins	Antioxidant, astringent, antimicrobial
Saponins	Arachidins, Soyasaponins	Antimicrobial, anti-inflammatory, immune-modulatory
Phytosterols	Beta-sitosterol, Stigmasterol	Cholesterol-lowering, anti-inflammatory
Fatty Acids	Oleic acid, Linoleic acid	Anti-inflammatory, heart health
Vitamins	Vitamin E (Tocopherol), Vitamin C	Antioxidant, immune support, skin health
Minerals	Potassium, Magnesium, Calcium	Electrolyte balance, bone health, muscle function
Proteins	Essential amino acids	Growth, repair, enzyme function
Carotenoids	Beta-carotene, Lutein	Antioxidant, eye health, skin health
Alkaloids	Trigonelline, Caffeine	Neurostimulant, anti-diabetic, lipolytic
Enzymes	Protease, Lipase	Protein and fat digestion
Polysaccharides	Arabinogalactan, Xylan	Immunomodulatory, prebiotic
Phytohormones	Gibberellins, Cytokinins	Growth regulation, cell division
Polyphenols	Resveratrol, Curcumin	Antioxidant, anti-inflammatory, anticancer

These compounds exhibit a wide range of biological activities, including antioxidant, anti-inflammatory, antimicrobial, anticancer, and immune-modulatory effects. The synergistic interactions among these bioactive compounds enhance the therapeutic potential of *Arachis hypogaea* leaves.

3.2 Methods of Phytochemical Analysis: To accurately identify and quantify the bioactive compounds in *Arachis hypogaea* leaves, various phytochemical analysis methods are employed. These methods are crucial for understanding the chemical composition and potential health benefits of the leaves. The different methods as below description:

3.3. Extraction Methods

Solvent Extraction: This method involves using solvents such as methanol, ethanol, acetone, or water to extract phytochemicals from plant materials. The choice of solvent depends on the polarity of the target compounds.

Procedure: The plant leaves are dried and ground into a fine powder. The powder is then mixed with the chosen solvent in a specific ratio and allowed to soak for a period, typically ranging from a few hours to several days, with occasional stirring. After soaking, the mixture is filtered to separate the solvent containing the dissolved phytochemicals from the plant residue.

Ultrasound-Assisted Extraction (UAE): This method uses ultrasonic waves to enhance the extraction efficiency by disrupting the plant cell walls, facilitating the release of phytochemicals into the solvent.

Procedure: The plant material is mixed with the solvent and subjected to ultrasonic waves using an ultrasonic bath or probe. The ultrasonic waves generate cavitation bubbles that collapse and create micro-jets, increasing the solvent's penetration into the plant material and enhancing the mass transfer of phytochemicals.

Supercritical Fluid Extraction (SFE): This method uses supercritical CO_2 as a solvent to extract non-polar compounds from plant materials. Supercritical CO_2 exhibits properties of both a liquid and a gas, making it an effective solvent for extraction.

Procedure: The plant material is placed in an extraction vessel, and supercritical CO_2 is pumped through it under controlled temperature and pressure conditions. The supercritical CO_2 dissolves the target compounds, which are then separated from the CO_2 in a downstream separator.

These extraction methods are crucial for isolating and concentrating the phytochemicals present in *Arachis hypogaea* leaves, allowing for subsequent analysis and evaluation of their therapeutic potential. Each method has its own advantages and limitations, and the choice of method depends on the specific compounds of interest and the resources available [28-29].

3.2.2 Chromatographic Techniques

High-Performance Liquid Chromatography (HPLC): Separates and quantifies individual compounds, commonly used for flavonoids, phenolic acids, and saponins.

Gas Chromatography-Mass Spectrometry (GC-MS): Analyzes volatile compounds and fatty acids.

Thin Layer Chromatography (TLC): Provides a quick, qualitative analysis of various phytochemicals.

3.2.3 Spectroscopic Methods

UV-Vis Spectroscopy: Measures absorbance of UV and visible light to quantify compounds like flavonoids and phenolic acids.

Fourier-Transform Infrared Spectroscopy (FT-IR): Identifies functional groups and molecular structures.

Nuclear Magnetic Resonance (NMR) Spectroscopy: Provides detailed information on molecular structure and dynamics.

Mass Spectrometry (MS)

Liquid Chromatography-Mass Spectrometry (LC-MS): Combines HPLC with mass spectrometry for precise identification and quantification of compounds.

Matrix-Assisted Laser Desorption/Ionization (MALDI-MS): Analyzes large biomolecules like proteins and polysaccharides.

Bioassays

Antioxidant Assays: DPPH, ABTS, and FRAP assays measure the antioxidant capacity of extracts.

Antimicrobial Assays: Disk diffusion and MIC assays determine antimicrobial activity.

Anti-inflammatory Assays: Measure the inhibition of enzymes like COX-2 or release of inflammatory markers.

Other Techniques

High-Performance Thin Layer Chromatography (HPTLC): Advanced form of TLC for better resolution and quantification.

Capillary Electrophoresis: Separates compounds based on their charge and size [26-30].

These methods, researchers can comprehensively analyze the phytochemical composition of *Arachis hypogaea* leaves, leading to a better understanding of their medicinal properties and potential applications in health and disease management.

4. Therapeutic applications of *Arachis hypogaea* leaves

4.1 Anti-inflammatory Properties: The leaves of *Arachis hypogaea* (peanut) exhibit significant anti-inflammatory properties due to their rich content of bioactive compounds such as flavonoids, phenolic acids, tannins, and saponins. [30-32]. These compounds play a crucial role in modulating the inflammatory response, making peanut leaves a potential natural remedy for inflammatory conditions.

Key Bioactive Compounds and Mechanisms: They compounds and mechanism as below followings:

- **Flavonoids (e.g., Quercetin, Kaempferol):** These compounds inhibit the activity of pro-inflammatory enzymes like cyclooxygenase (COX) and lipoxygenase (LOX), thereby reducing the synthesis of pro-inflammatory mediators such as prostaglandins and leukotrienes. They also modulate signaling pathways involved in inflammation, including the NF-κB pathway, leading to a decrease in the production of inflammatory cytokines.
- **Phenolic Acids (e.g., Caffeic acid, Gallic acid):** Phenolic acids possess strong antioxidant properties that help mitigate oxidative stress, a key factor in the inflammatory process. By scavenging free radicals and reducing oxidative damage, these compounds lower the overall inflammatory response.
- Saponins (e.g., Arachidins, Soyasaponins): Saponins have been shown to modulate the immune system and reduce inflammation by inhibiting the release of pro-inflammatory cytokines and reducing the infiltration of inflammatory cells into tissues [33-35]. The therapeutic

applications of *Arachis hypogaea* Leaves as anti-inflammatory properties discussed with key points in the Table 4 as follows.

Table 4: The list of application area with their respective research findings [31-37]

Application Area	Research Findings
Arthritis Management	Extracts from *Arachis hypogaea* leaves can alleviate symptoms of arthritis by reducing joint inflammation and pain.
Skin Conditions	Beneficial in treating eczema, psoriasis, and dermatitis. Topical application helps soothe irritated skin and reduce redness and swelling.
Gastrointestinal Inflammation	Potential in managing conditions like colitis by reducing production of inflammatory mediators in the gut, alleviating symptoms and promoting healing.
Respiratory Inflammation	May help reduce inflammation associated with asthma and bronchitis, extending the anti-inflammatory effects to the respiratory system.

The anti-inflammatory properties of *Arachis hypogaea* leaves highlight their potential as a natural remedy for various inflammatory conditions. The presence of flavonoids, phenolic acids, tannins, and saponins plays a crucial role in modulating inflammation, making peanut leaves a promising candidate for further research and development in anti-inflammatory therapies.

4.2 Antioxidant Effect

Arachis hypogaea (peanut) leaves exhibit significant antioxidant properties due to their rich content of various bioactive compounds, including flavonoids, phenolic acids, tannins, and vitamins. These compounds contribute to the leaves' ability to neutralize free radicals and protect cells from oxidative stress, which is a key factor in the prevention and management of numerous chronic diseases.

Key Bioactive Compounds and Mechanisms

- **Flavonoids (e.g., Quercetin, Kaempferol):** These compounds have strong free radical scavenging abilities, which help in reducing oxidative stress and preventing cellular damage.
- **Phenolic Acids (e.g., Caffeic acid, Gallic acid):** Phenolic acids are effective antioxidants that protect biomolecules like DNA, proteins, and lipids from oxidative damage.
- **Tannins (e.g., Ellagic acid, Catechins):** Tannins exhibit potent antioxidant activity by chelating metal ions and neutralizing free radicals, thus preventing oxidative damage.
- **Vitamins (e.g., Vitamin E, Vitamin C):** These vitamins are well-known antioxidants that enhance the body's defense against oxidative stress by directly neutralizing free radicals and regenerating other antioxidants [37-40]. The list of therapeutic applications of *Arachis hypogaea* in Table 5 as following.

Table 5: The list of application areas in antioxidant effects [38-41]

Application Area	Research Findings
Cardiovascular Health	The antioxidant properties of peanut leaves help in reducing oxidative stress, protecting against oxidative damage to blood vessels, and reducing inflammation, thereby supporting heart health.
Neuroprotection	Antioxidants in the leaves protect neuronal cells from oxidative damage, which is implicated in neurodegenerative diseases like Alzheimer's and Parkinson's. This helps maintain cognitive function and reduces the risk of neurodegenerative conditions.
Anti-Aging	By combating oxidative stress, the antioxidants in peanut leaves reduce cellular damage, helping maintain skin health and reduce signs of aging such as wrinkles and fine lines.
Cancer Prevention	Antioxidant compounds in peanut leaves help prevent the initiation and progression of cancer by protecting cells from DNA damage and reducing oxidative stress-induced mutations.

This table summarizes the research findings and applications of the antioxidant properties of *Arachis hypogaea* leaves in various health conditions.

4.3 Antimicrobial Activity: *Arachis hypogaea* (peanut) leaves exhibit notable antimicrobial properties, which are attributed to their diverse range of bioactive compounds such as flavonoids, phenolic acids, tannins, and saponins [19, 21-22]. These compounds contribute to the leaves' ability to inhibit the growth of various pathogens, including bacteria, fungi, and viruses, making them potential natural alternatives for antimicrobial therapy.

Key Bioactive Compounds and Mechanisms

- **Phenolic Acids (e.g., Caffeic acid, Gallic acid):** Phenolic acids exert antimicrobial effects by destabilizing microbial cell walls and membranes, and by interfering with microbial enzyme activity.
- **Tannins (e.g., Ellagic acid, Catechins):** Tannins precipitate microbial proteins, disrupt cell membranes, and inhibit microbial adhesion and colonization.
- **Saponins (e.g., Arachidins, Soyasaponins):** Saponins interact with microbial cell membranes, causing increased permeability and cell lysis, thereby killing the microbes [42]. The therapeutic application in antimicrobial activity detection discussed in the given Table 6 as below followings.

Table 6: The list of application as antimicrobial activity of peanut [40-42]

Application Area	Research Findings
Bacterial Infections	Peanut leaf extracts have shown effectiveness against bacterial pathogens, including Staphylococcus aureus and Escherichia coli. The antimicrobial compounds inhibit bacterial growth and reduce the risk of infections.
Fungal Infections	Antifungal properties have been demonstrated against pathogens such as Candida albicans and Aspergillus species. The bioactive compounds inhibit fungal growth, useful in treating fungal infections.
Viral Infections	Studies suggest antiviral properties that may help in inhibiting virus replication, reducing the severity and spread of viral infections.
Wound Healing	The antimicrobial properties support wound healing by preventing microbial infections, promoting faster and cleaner healing processes.

This table summarizes the research findings and applications of the antimicrobial properties of *Arachis hypogaea* leaves in various health conditions. The antimicrobial activity of *Arachis hypogaea* leaves highlights their potential as natural antimicrobial agents. The presence of flavonoids, phenolic acids, tannins, and saponins plays a crucial role in inhibiting the growth of various pathogens

4.4 Anticancer Potential: *Arachis hypogaea* (peanut) leaves have shown promising anticancer potential attributed to their rich content of bioactive compounds such as flavonoids, phenolic acids, tannins, and polyphenols. These compounds exhibit various mechanisms that contribute to their ability to inhibit cancer cell proliferation, induce apoptosis (programmed cell death), and prevent angiogenesis (formation of new blood vessels to tumors).

Key Bioactive Compounds and Mechanisms: Anticancer potential of *Arachis hypogaea* as following:

Flavonoids (e.g., Quercetin, Kaempferol): Flavonoids have been found to inhibit cancer cell growth by targeting multiple signaling pathways involved in cell proliferation, survival, and metastasis. They also exhibit antioxidant properties that protect cells from oxidative stress-induced DNA damage.

- **Phenolic Acids (e.g., Caffeic acid, Gallic acid):** Phenolic acids possess anti-cancer effects through their ability to induce apoptosis, inhibit angiogenesis, and modulate inflammatory pathways that promote tumor growth.
- **Polyphenols (e.g., Resveratrol, Curcumin):** Polyphenols exhibit diverse anticancer effects, including inhibiting cancer cell growth, inducing cell cycle arrest, and promoting apoptosis. They also possess antioxidant and anti-inflammatory properties [43]. The therapeutic applications of Arachis hypogaea leaves as anticancer potential with their areas in the Table 7 below followings:

Table 7: The list of applications as anticancer potential with their areas [42-44]

Cancer Type	Research Findings
Breast Cancer	Compounds from peanut leaves inhibit breast cancer cell growth and induce apoptosis, suggesting potential in breast cancer prevention and treatment.
Colon Cancer	Bioactive compounds in peanut leaves inhibit colon cancer cell proliferation, induce cell cycle arrest, and apoptosis, showing promise in colon cancer management.
Prostate Cancer	Certain compounds in peanut leaves inhibit prostate cancer cell growth and modulate cancer signaling pathways, offering therapeutic benefits for prostate cancer patients.
Lung Cancer	Peanut leaf extracts exhibit anticancer properties in lung cancer cells, inhibiting cell proliferation and inducing apoptosis, indicating potential in lung cancer treatment.

This table summarizes the research findings and applications of the anticancer potential of *Arachis hypogaea* leaves in various cancer types. The anticancer potential of *Arachis hypogaea* leaves, attributed to their diverse array of bioactive compounds, presents promising avenues for cancer prevention and treatment.

4.5 Recent trends in research of *Arachis Hypogaea*

Recent research trends in *Arachis hypogaea* (peanut) leaf study have shown significant advancements and diverse applications. Firstly, there's been a notable focus on the genomic and molecular analysis of peanut leaves to understand their role in disease resistance, particularly against fungal pathogens. Researchers are employing advanced genomic techniques to identify specific genes that confer resistance, aiming to breed more resilient peanut varieties. Secondly, studies are exploring the biochemical properties of peanut leaves, including their antioxidant and antimicrobial activities, which have potential applications in developing natural pesticides and health supplements [45]. Thirdly, there is an increasing interest in the environmental impact of peanut cultivation, with research investigating the role of peanut leaves in carbon sequestration and soil health improvement, contributing to sustainable agriculture practices. Fourthly, peanut leaves are being studied for their nutritional content and potential use in animal feed, which could provide a cost-effective and nutritious alternative in livestock farming. Lastly, innovative research is looking into the use of peanut leaf extracts in pharmaceuticals and cosmetics, leveraging their bioactive compounds for developing new products that promote skin health and wound healing. The importance of recent trends for the herbal impact discussed in the given below description.

4.6 Innovative Applications

- **Nanotechnology-Based Formulations:** Researchers are exploring the use of nanotechnology to develop innovative formulations of *Arachis hypogaea* leaf extracts. Nanoparticles can enhance the bioavailability and targeted delivery of bioactive compounds, improving their therapeutic efficacy in various applications.
- **Biodegradable Packaging Materials:** The development of biodegradable packaging materials using *Arachis hypogaea* leaf extracts is gaining attention. These materials offer a sustainable and environmentally friendly alternative to conventional plastics, with added antimicrobial and antioxidant properties.
- **Cosmeceutical Products:** The incorporation of *Arachis hypogaea* leaf extracts into cosmeceutical products is on the rise. These extracts offer antioxidant, anti-inflammatory, and antimicrobial benefits, making them ideal for skincare and haircare formulations targeting aging, inflammation, and microbial infections.

4.7 Integrative Approaches in Therapy

- **Phytopharmaceutical Combinations:** Researchers are investigating the synergistic effects of combining *Arachis hypogaea* leaf extracts with other phytochemicals or herbal extracts. These combinations enhance therapeutic outcomes by targeting multiple pathways and offering broader health benefits.
- **Nutraceutical Supplementation:** Integrating *Arachis hypogaea* leaf extracts into nutraceutical supplements is gaining popularity. These supplements provide a convenient way to access the bioactive compounds' health benefits, supporting overall well-being and disease prevention.

- **Traditional Medicine Integration:** Efforts are underway to integrate *Arachis hypogaea* leaves into traditional medicine systems such as Ayurveda and Traditional Chinese Medicine (TCM). This integration aims to leverage the plant's therapeutic properties within established frameworks of holistic health and wellness [44-46].

The recent trends in research on *Arachis hypogaea* leaves reflect a shift towards innovative applications and integrative approaches in therapy. From nanotechnology-based formulations to traditional medicine integration, the versatility and therapeutic potential of these leaves are being explored across diverse fields, paving the way for novel healthcare solutions and sustainable practices. These trends reflect a multidisciplinary approach to peanut leaf research, highlighting their agricultural, environmental, and commercial significance.

5. Future Directions and Perspectives

Future directions for *Arachis hypogaea* (peanut) research are poised to leverage advancements in biotechnology, environmental science, and commercial applications. Genomic editing techniques, such as CRISPR, will likely play a crucial role in developing peanut varieties with enhanced disease resistance, drought tolerance, and improved nutritional profiles. Furthermore, expanding the study of peanut leaves' bioactive compounds could lead to innovative uses in pharmaceuticals, nutraceuticals, and cosmetics [47]. The several key points in the future directions and perspectives for *Arachis hypogaea* as below following:

- **Bioavailability Enhancement:** Future research should focus on improving the bioavailability of bioactive compounds from *Arachis hypogaea* leaves. Utilizing advanced delivery systems like nanoencapsulation or lipid-based formulations can enhance absorption and efficacy.
- **Clinical Trials:** Conducting well-designed clinical trials is crucial to validate the therapeutic efficacy and safety of *Arachis hypogaea* leaf extracts in humans. This includes investigating their potential in managing specific health conditions such as arthritis, cancer, and inflammatory disorders.
- **Standardization and Quality Control:** Establishing standardized methods for extraction, characterization, and quality control of *Arachis hypogaea* leaf extracts is essential for ensuring consistency and reproducibility in research and product development.
- **Safety Assessment:** Comprehensive safety assessments, including toxicity studies and long-term exposure evaluations, are necessary to determine the safety profile of *Arachis hypogaea* leaf extracts for therapeutic use.
- **Exploration of Synergistic Effects:** Investigating the potential synergistic effects of combining *Arachis hypogaea* leaf extracts with other herbal extracts or pharmaceutical agents can lead to novel therapeutic combinations with enhanced efficacy and reduced side effects.
- **Sustainable Cultivation Practices:** Promoting sustainable cultivation practices for *Arachis hypogaea* plants, such as organic farming methods and biodiversity conservation, can ensure a continuous and reliable supply of high-quality leaves for medicinal purposes.
- **Consumer Education:** Educating healthcare professionals and consumers about the health benefits, proper usage, and potential risks of *Arachis hypogaea* leaf extracts is essential for promoting informed decision-making and responsible use.
- **Regulatory Considerations:** Collaboration with regulatory agencies to establish clear guidelines and regulations for the production, labeling, and marketing of *Arachis hypogaea* leaf-derived products is necessary to ensure their safety and efficacy in the market.
- **Exploration of Novel Applications:** Continuously exploring novel applications of *Arachis hypogaea* leaves beyond traditional uses can uncover new therapeutic potentials, such as in functional foods, nutraceuticals, and cosmeceuticals [45-50].

These future directions and perspectives, the research and utilization of *Arachis hypogaea* leaves can advance significantly, leading to enhanced healthcare options and sustainable practices. Integrating precision agriculture technologies can optimize peanut cultivation, making it more sustainable and efficient.

6. Conclusion

This comprehensive review focused on the significant therapeutic potential of *Arachis hypogaea* leaves, which have been traditionally overlooked in favour of the plant's seeds. The exploration of the bioactive compounds found in these leaves reveals their impressive range of medicinal properties, including anti-inflammatory, antioxidant, antimicrobial, and anticancer activities. The review also highlights recent trends and innovative applications in the field, pointing to a growing interest in integrating these leaves into modern therapeutic regimes. In conclusion, *Arachis hypogaea* leaves present a valuable yet underexplored resource in natural therapeutics. This review aims to elevate the recognition of their medicinal potential and encourages further scientific inquiry and clinical validation. By addressing the identified gaps and leveraging recent advancements, the therapeutic applications of peanut leaves can be more effectively harnessed, potentially leading to the development of novel, plant-based treatments.

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8. Author contribution

All author contributed equally to this review completion. They all conducted an extensive review of the literature, gathered and examined the data. Additionally, all authors have provided their consent for the submission of the final manuscript version.

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10. Ethical consideration

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11. Conflict of interest

There are no conflicts of interest among the corresponding author and all co-authors involved in the completion of the work.

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