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Reviewing African Antitussive Plants: Traditional Uses, Phytochemistry, and Pharmacology

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Abstract

This review explores the therapeutic potential of African antitussive plants by examining their traditional uses, phytochemical properties, and pharmacological evidence. It highlights the historical and cultural significance of these plants in African medicine and provides an overview of the key phytochemicals associated with their antitussive effects. The review also evaluates scientific studies that support the efficacy of these plants, including in vitro, in vivo, and clinical research. Additionally, it addresses challenges in standardizing and conserving these valuable resources while discussing opportunities for integrating traditional knowledge with modern healthcare practices. This comprehensive analysis aims to advance the understanding of African antitussive plants and their potential contributions to global health.

Keywords: Antitussive plants; African traditional medicine; Phytochemicals; Pharmacological evidence; Ethnopharmacology

Introduction

Traditional medicine in Africa is a significant part of African culture, serving as the primary healthcare system for many communities (Builders, 2019). Traditional healers play a crucial role in preserving and transmitting knowledge about medicinal plants, rituals, and therapeutic techniques (Jacob et al., 2024). Medicinal plants have significant research and healthcare potential due to their potential to offer safe, affordable, and effective treatments for various ailments (Jamshidi-Kia et al., 2017). In Africa, where access to modern healthcare may be limited, these plants provide a vital resource for managing health conditions (Chirwa, 2016; Wireko & Béland, 2013).

Respiratory conditions, such as coughs, colds, and bronchitis, are common health issues in Africa, exacerbated by factors like pollution, indoor cooking smoke, and infectious diseases like tuberculosis (Almusaed & Almssad, 2018; Pérez-Padilla et al., 2010). Antitussive plants, often readily available and affordable, play a critical role in addressing these conditions (Saraswathy et al., 2014; Ziment, 2002). This study aims to document traditional uses of antitussive plants in Africa, identify and classify phytochemicals, evaluate their pharmacological efficacy, and propose strategies for integrating tradition-

al antitussive plants into modern healthcare systems.

Methodology

This study conducted a comprehensive literature search and selection process using various academic databases, including PubMed, Scopus, Web of Science, Google Scholar, Google Research, Research gate, PDFDrive, and AGORA (Onwuegbuzie, 2016). Alertes were created for continious documentaion. Documents were captured and managed using Zotero and Mendeley. The research focused on several key aspects of African antitussive plants, pulmonary deseases, asthm, colds and cough suppressants, namely their traditional uses, phytochemical properties, pharmacological evidence, and conservation issues.

In addition to exploring the therapeutic aspects, the study also gathered information on the conservation status of these plants, sustainable harvesting practices, and the challenges associated with standardizing herbal preparations. This holistic approach aims to provide a well-rounded understanding of the plants' current and potential roles in healthcare.

Thematic analysis was used to uncover recurring themes in the collected data; enabling a comparison of the effectiveness of various antitussive plants. Furthermore, the study identified trends in the field, particularly advancements in phytochemical analysis and emerging insights into the pharmacological effects of these plants. The findings were synthesized to present a detailed overview of the therapeutic potential of African antitussive plants. This synthesis also addressed the difficulties related to standardizing and conserving these plants. Finally, the study offered recommendations for future research directions, conservation strategies, and the integration of traditional medicine practices into modern healthcare frameworks.

The History and Evolution of Traditional Medicine in Africa

The historical Roots of Traditional Medicine

Traditional medicine in Africa has a rich history dating back thousands of years, with roots in the use of natural resources, particularly plants, for treating ailments (Jamshidi-Kia et al., 2017). Over time, it evolved through adaptation to changing environments, social structures, and health challenges. Over time, healing systems evolved through practical experience, integrating botanical knowledge, spiritual beliefs, and ritualistic practices. The effectiveness of traditional healing methods is often attributed to the integration of plant remedies with the invocation of ancestral or spiritual forces (Mokgobi, 2012; Ozioma & Chinwe, 2019). Despite colonialism's introduction of Western medicine, traditional medicine persisted as a vital healthcare resource, particularly in rural areas with limited access to modern facilities. Traditional healers and herbalists play a central role in healthcare, providing holistic care.

Historical Foundations

Traditional medicine in Africa has a deep history, dating back thousands of years (Chaitanya et al., 2021; Janzen & Green, 2008; McFarlane, 2015). Early African societies relied on natural resources, particularly plants, to treat common ailments. Over time, these practices evolved, combining botanical knowledge with spiritual and ritualistic elements. The effectiveness of traditional healing is often linked to the invocation of ancestral or spiritual forces, and rituals and ceremonies are crucial in the therapeutic process (Jacob et al., 2024). Despite external influences like colonialism and Western medicine, traditional medicine continues to play a vital role in healthcare, particularly in rural areas with limited access to modern facilities. Traditional healers and herbalists are central figures in traditional healthcare, offering holistic and culturally relevant treatments.

Ethnobotanical Surveys and Studies

Ethnobotanical surveys play a crucial role in documenting and preserving traditional knowledge about medicinal plants, including those used for their antitussive properties. Key studies have contributed to the understanding of antitussive plants in Africa, highlighting their traditional uses and scientific validation (Biharee et al., 2024). Some notable studies include "Ethnobotanical Survey of Medicinal Plants Used in the Treatment of Coughs in Nigeria (Adesina et al., 2017b; Lawal et al., 2020), "Traditional Medicine and Antitussive Plants in Nigeria: A Review (Adesina et al., 2017a), Ethnobotanical study of antitussive plants used in traditional medicine

by Abbey et Krobou populations, in the south of Côte d'Ivoire (N'Guessan et al., 2015).

Key methodologies used in ethnobotanical research include field surveys and interviews, ethnographic studies, literature review and data compilation, phytochemical analysis, and collaboration with local experts (Heinrich et al., 2009; Martin, 2010). Field surveys involve traveling to different regions to collect data on plant species and their traditional uses, while ethnographic studies provide a detailed account of the cultural practices and beliefs associated with medicinal plants. Literature reviews help identify gaps in knowledge and provide a broader context for understanding traditional practices (Rozas & Klein, 2010).

Cultural and Spiritual Significance of Antitussive Plants

Antitussive plants in African cultures hold significant symbolic and spiritual significance. They are considered symbols of protection, purity, ancestral connection, and healing (Adeleye et al., 2021). In West Africa, *Ocimum gratissimum* is valued for its medicinal properties and wards off evil spirits (Ogidi & Emaikwu, 2024). In Central Africa, Alstonia boonei is associated with ancestral spirits, while in East Africa, Warburgia ugandensis is associated with renewal and healing.

The use of antitussive plants in Africa is often accompanied by rituals and practices that enhance their therapeutic effects and integrate them into the cultural fabric of the community. These include ritual preparations, ceremonial use, and healing rituals. Traditional healers often incorporate antitussive plants into broader healing rituals, involving prayer, divination, and the invocation of spiritual forces.

The integration of spiritual beliefs with medicinal use reflects a holistic approach to health that encompasses both physical and metaphysical aspects of illness (Iwu, 1993). Spiritual cleansing and healing are often accompanied by the use of antitussive plants. In traditional medicine, antitussive plants are part of a broader holistic approach that includes dietary recommendations, lifestyle changes, and spiritual practices. Community and ancestral involvement are also key aspects of the healing process.

Phytochemical Constituents of African Antitussive Plants

Major Classes of Phytochemicals in Antitussive Plants

Antitussive plants contain various phytochemicals, including alkaloids, flavonoids, saponins, and terpenoids (Biharee et al., 2024). Alkaloids are naturally occurring compounds with potent therapeutic properties, including cough suppression. They can be classified into isoquinoline, indole, and quinoline alkaloids, each with distinct effects and mechanisms of action. Isoquinoline alkaloids, found in plants like *Papaver somniferum*, suppress the cough reflex by acting on the central nervous system. Indole alkaloids, found in plants like *Vinca*, modulate neurotransmitter levels, influencing cough reflex sensitivity. Quinoline alkaloids, found in plants like *Chinchona* species, impact respiratory conditions through smooth muscle relaxation and mucosal irritation.

Flavonoids are polyphenolic compounds known for their antioxidant and anti-inflammatory properties. They help manage respiratory conditions and alleviate coughs by scavenging free radicals and reducing oxidative stress. Saponins and glycosides with diverse biological activities modulate mucus production and cough reflex suppression. They have surfactant properties and expectorant effects, facilitating the clearance of mucus from the respiratory tract.

Terpenoids, a large class of aromatic compounds derived from plants, have bronchodilatory and soothing effects. They help relax the smooth muscles of the airways, making breathing easier, which is particularly useful in conditions like asthma and bronchitis. Research supports the use of terpenoids in managing respiratory conditions, reducing cough frequency, and improving respiratory function.

Techniques for Phytochemical Analysis

Phytochemical analysis is crucial for understanding the therapeutic properties of plant materials, especially medicinal plants. Techniques like solvent extraction, steam distillation, and supercritical fluid extraction are used to extract active compounds (Harborne, 1998; Velavan, 2015). Chromatographic techniques like HPLC and GC-MS are used to separate, identify, and quantify these compounds.

Spectroscopic methods provide detailed insights into their molecular structure (Abdelkhalek et al., 2023).

Various extraction methods are employed to isolate and concentrate active compounds from plant tissues. Solvent extraction is a common method, using solvents like ethanol, methanol, chloroform, or hexane to dissolve and extract compounds from plant materials. Steam distillation is used for extracting essential oils and volatile compounds, while cold pressing is used for extracting essential oils from citrus fruits and seeds. Supercritical fluid extraction (SFE) uses supercritical fluids, usually carbon dioxide, to extract phytochemicals with minimal thermal degradation.

Chromatographic techniques (HPLC, GC-MS) are essential for separating, identifying, and quantifying phytochemicals in plant extracts. HPLC is used to profile flavonoid content in plants like *Hibiscus sabdariffa* and to quantify alkaloids in *Catharanthus roseus*. GC-MS combines the separation capabilities of gas chromatography with the identification capabilities of mass spectrometry for analyzing volatile and semi-volatile compounds, including terpenoids and essential oils.

Spectroscopic methods (NMR, IR, and UV) provide detailed information about the molecular structure and functional groups of phytochemicals. NMR spectroscopy provides information about the chemical environment of specific nuclei, while IR spectroscopy identifies functional groups and characterizes molecular bonds based on their absorption of infrared radiation. UV spectroscopy is commonly used to analyze flavonoids and phenolic compounds in plant extracts.

Bioactive Compounds and their Pharmacological Mechanisms

African antitussive plants contain a variety of bioactive compounds, including alkaloids like codeine and noscapine, flavonoids like quercetin and kaempferol, saponins like glycyrrhizin, and terpenoids like menthol and cineole (Abdelkhalek et al., 2023; Ziment, 2002). These compounds work through anti-inflammatory effects, bronchodilation, expectoration, and central nervous system modulation to alleviate cough symptoms. Codeine, found in opium poppy plants, suppresses the cough reflex in the central nervous system, while noscapine reduces cough frequency. Flavonoids like quercetin and kaempferol have antioxidant and anti-inflammatory properties, while kaempferol has anti-inflammatory effects. Saponins, like glycyrrhizin, have expectorant properties that help in clearing mucus and alleviating cough. Terpenoids like menthol and cineole play a crucial role in bronchodilation, relaxing airway muscles, and reducing cough frequency. Some alkaloids suppress the cough reflex in the brain, providing relief.

Many African antitussive plants contain a combination of bioactive compounds that work synergistically to enhance their therapeutic effects. For example, Eucalyptus globulus contains both cineole and other anti-inflammatory compounds, resulting in a combined action that reduces cough and improves respiratory function (Ziment, 2002). The presence of multiple active compounds in a single plant extract can lead to enhanced efficacy, improving the overall therapeutic outcome and reducing the likelihood of developing resistance or side effects.

In traditional medicine, polyherbal formulations often combine multiple plant species to leverage their synergistic effects, providing a comprehensive treatment approach for coughs and respiratory issues (Barik et al., 2015; Mule Geetanjli et al., 2023).

Pharmacological Studies on African Antitussive Plants

In Vitro Studies

In vitro studies are crucial for understanding the pharmacological properties of antitussive plants. These studies use cell-based assays to evaluate the effects of plant extracts and isolated compounds on cellular systems, providing insights into their mechanisms of action and potential therapeutic benefits. Common assays include cell viability assays, anti-inflammatory assays, bronchodilator assays, and mucus production and expectorant assays.

Key findings from in vitro studies on African antitussive plants include anti-inflammatory effects, bronchodilatory effects, expectorant effects, cytotoxicity, and safety. *Hibiscus sabdariffa* (roselle) extracts have shown significant *Ramulus mori*, *Salvia plebeia*, and *Anthriscus sylvestris* anti-asthmatic and antitussive activities without hepatotoxicity (An et al., 2021), while *Glycyrrhiza glabra* (licorice)

extracts have been found to exert an inhibitory effect on mucus hyperproduction both in vivo and in vitro (Nishimoto et al., 2010).

However, in vitro approaches have limitations, such as the lack of systemic interactions, cell line variability, and complex interactions. Additionally, dosage and concentration limitations may not always reflect the levels achievable in clinical settings or the therapeutic doses used in traditional medicine. Finally, reproducibility and standardization can be affected by variations in extract preparation, assay conditions, and experimental protocols.

In Vivo Studies

In vivo studies are used to evaluate the efficacy and safety of antitussive plants and their compounds in a more complex biological system compared to in vitro assays. Common animal models used for testing antitussive effects include mice and rats, guinea pigs, and rabbits (Meher, 2012; Raja et al., 2014; Šutovská, Fraňová, et al., 2009). Key in vivo studies on African antitussive plants include ginger, roselle, and peppermint.

Key findings include significant reductions in cough frequency and severity, anti-inflammatory effects, bronchodilatory effects, and expectorant effects (Adejayan et al., 2019; Koffuor et al., 2014). Plant-based treatments often offer a more balanced profile with fewer side effects compared to conventional drugs. They also have a favorable safety profile, minimal side effects, and a broader spectrum of activity.

Traditional plant-based remedies are often more affordable and accessible, especially in regions where these plants are native. They are also sourced locally and sustainably, making them more accessible. Conventional drugs can be more expensive and less accessible in low-resource settings. Comparing these treatments with conventional drugs helps establish their place in modern therapeutic strategies and supports the integration of traditional medicine into contemporary healthcare practices.

Clinical Studies and Human Trials

Clinical research on African antitussive plants is crucial for translating preclinical findings into practical treatments for human use. Trials are systematic studies conducted to evaluate the safety and efficacy of specific plant extracts or compounds in human participants (Keter et al., 2013). Key clinical trials include *Zingiber officinale* (Ginger), *Mentha piperita* (Peppermint), and *Glycyrrhiza glabra* (Licorice).

Efficacy and safety profiles observed in human trials show that several African antitussive plants are effective at managing cough and respiratory conditions (Akunne (formerly Okoye) et al., 2014; Keter et al., 2013). They have been compared to conventional drugs, and their safety profiles have generally been favorable (Keter et al., 2013). Long-term studies are less common but are crucial for assessing the sustained safety of plant-based treatments.

Challenges and considerations include quality control and interactions with conventional medications. Integrating African antitussive plants into modern healthcare offers opportunities for complementary treatments, the development of new phytomedicines, and improved public health outcomes (Fayiah et al., 2024). Establishing regulatory frameworks for the use of antitussive plants in modern medicine is essential for ensuring their safety and efficacy (Kaggwa et al., 2022). Supporting research and policy initiatives that promote the integration of traditional plant-based treatments into mainstream healthcare can enhance their acceptance and utilization.

Mechanisms of Action

The mechanisms of action of antitussive plants are crucial for understanding their therapeutic potential. These plants work by inhibiting pro-inflammatory cytokines, inhibiting inflammatory enzymes, and modulating NF-κB (Pourova et al., 2023). They also relax airway smooth muscle, promoting airflow and improving airflow (Šutovská, Nosál'ová, et al., 2009). Some plants inhibit histamine release, reducing bronchoconstriction and cough (Shah et al., 2012). They also influence calcium channel activity, facilitating bronchodilation and improving respiratory function (Karal & Çelik, 2022). Expectorant and soothing properties play a role in cough suppression.

They promote mucus clearance by reducing mucus viscosity and promoting mucus clearance (Franova et al., 2006). Soothing properties provide relief by coating and soothing the mucous membranes of the respiratory tract, reducing irritation and coughing. Some plants have anti-irritant effects, reducing airway irritation and sensitivity and contributing to a decrease in cough reflex (Nosalova et al., 2013). These mechanisms provide a scientific basis for their traditional use and support their potential integration into modern therapeutic practices. Overall, understanding the mechanisms of action of African antitussive plants is essential for elucidating their therapeutic potential.

Case Studies of Prominent African Antitussive Plants

Scoparia dulcis

This plant is also known as sweet broomweed, is a small herbaceous plant found in tropical and subtropical regions worldwide. It has a slender stem, lanceolate leaves, and small, white, or pale purple flowers. The fruit is a small capsule containing numerous tiny seeds. *Scoparia dulcis* has been traditionally used in traditional medicine for its antitussive, anti-inflammatory, antidiabetic, antimicrobial, and wound healing properties (Koffuor et al., 2014). Its phytochemical constituents include flavonoids, tannins, alkaloids, and terpenoids (Wankhar et al., 2015). Recent research has focused on its potential pharmacological benefits, suggesting significant therapeutic potential. Despite being considered a weed in some regions due to its fast growth and adaptability, its medicinal value has led to increased interest in its cultivation and sustainable use.

Ocimum gratissimum

Various cultures have traditionally used African basil, also known as clove basil, for its medicinal properties, which include cough suppression and antitussive effects (Adesina et al., 2017b; Imosemi, 2020; Ozolua & DI, 2016). The plant's leaves are rich in essential oils, including eugenol, thymol, and camphor, which have known respiratory benefits (Enegide & Charles C, 2021). Other phytochemicals, such as flavonoids and phenolic acids, also contribute to its antitussive effects. Traditional preparations include teas, infusions, and decoctions to relieve coughs and other respiratory conditions. Research has shown that extracts from the plant have significant antitussive effects, including reduced coughing induced by chemical irritants. The plant's antimicrobial and antibacterial effects are crucial for treating respiratory infections. Potential applications include herbal remedies and complementary medicine. However, dosage and preparation methods are important factors that can affect its efficacy and safety. Further clinical research is needed to establish standardized dosages and formulations; for effective cough suppression in humans.

Lannea microcarpa

Lannea microcarpa, also known as the small-fruited lannea, is a tree species native to tropical Africa, found in savannah and forested regions. Its phytochemical profile supports its pharmacological properties, including antitussive, expectorant, and anti-inflammatory effects. Traditional African medicine uses Lannea microcarpa to treat coughs and other respiratory conditions, believed to have antitussive and expectorant properties (Maroyi, 2018). Preparation methods include infusions and decoctions made from leaves, bark, or roots.

The plant holds significant cultural significance in various African communities and is often used in combination with other herbs to enhance its therapeutic effects. Indigenous knowledge about Lannea microcarpa's medicinal uses has been preserved through oral traditions and practice.

Phytochemical constituents of *L. microcarpa* include flavonoids, tannins, and saponins, which contribute to its medicinal properties (Malú et al., 2024). Extracts of *L. microcarpa* have demonstrated potential antitussive effects, expectorant properties, and anti-inflammatory activity. In vitro studies have shown that extracts can inhibit inflammatory and reduce oxidative stress, while animal studies have shown that Lannea microcarpa extracts can reduce cough frequency and severity (Hubert et al., 2015).

Alstonia boonei

Alstonia boonei, also known as stoolwood or patternwood, is a large tree native to tropical Africa known for its distinctive bark and medicinal properties. The plant is widely distributed across the region, thriving in well-drained, fertile soils and preferring humid and shaded environments. Traditional African medicine uses *Alstonia boonei* to treat coughs, bronchitis, and asthma. It is believed to have antitussive, expectorant, and anti-inflammatory properties. Preparation methods include decoctions and infusions made from the bark or leaves.

Phytochemical constituents of *A. boonei* include alkaloids, flavonoids, and saponins, which contribute to its medicinal properties (Shang et al., 2010). Extracts of the plant have demonstrated potential antitussive effects, such as soothing the respiratory tract and reducing inflammation (Paul et al., 2021). Its expectorant properties aid in mucus clearance from the respiratory system and exhibit anti-inflammatory activity.

In vitro and animal studies have shown that extracts of *A. boonei* can inhibit pro-inflammatory cytokines and reduce oxidative stress, contributing to its potential antitussive and anti-inflammatory properties (Mollica et al., 2022).

Cassia fistula

Also known as the golden shower tree, it is a plant known for its potential antitussive properties. Studies have shown that the plant contains bioactive compounds, including flavonoids, anthraquinones, and saponins, which contribute to its antitussive properties (Kumar & Bhat, 2024). In animal studies, *C. fistula* extracts have shown significant antitussive activity, similar to the effects of standard antitussive drugs like codeine (Bhakta et al., 1998). The plant's antitussive effect is believed to be due to its ability to modulate the central nervous system and alleviate respiratory tract irritation (Sharma et al., 2021). *C. fistula* has potential for human use, but more clinical trials are needed to confirm its safety and efficacy. Future research directions include clinical trials in humans to establish standardized dosages and explore its full potential. Its ethnobotanical context may provide further insights into its therapeutic potential.

Adhatoda vasica

A. vasica, also known as Malabar nut or Vasaka, is a medicinal plant with antitussive properties, particularly in traditional African medicine. Its key active compounds, including alkaloids like vasicine and vasicinone, have bronchodilator, expectorant, and antitussive properties, making it effective in managing respiratory issues (Shoaib, 2021). The plant's mechanism of action involves relaxing bronchial muscles and facilitating mucus expulsion from the airways, reducing cough frequency and severity. Traditional healers use the leaves to treat respiratory ailments like bronchitis, asthma, and persistent coughs (Sharma et al., 2018). Although specific studies on its use in African traditional medicine are limited, its well-established efficacy suggests it could play a significant role in traditional healthcare systems across Africa. Further research could enhance its application and contribute to better healthcare outcomes in Africa.

Eucalyptus globulus

Eucalyptus globulus, also known as the Tasmanian blue gum or Southern blue gum, is a tree species native to southeastern Australia (Sultana et al., 2016). It is widely cultivated for its fast growth, adaptability, and diverse uses. *E. globulus* has distinct juvenile and adult leaves, and produces white, fluffy flowers rich in nectar. It is native to Australia but has been introduced to Europe, South America, Africa, and Asia. *E. globulus* is renowned for its medicinal properties, including its high content of cineole (eucalyptol) in its leaves. Its wood is used in paper production, timber for construction, and essential oil for aromatherapy, cosmetics, and pharmaceuticals. However, its cultivation outside its native range has raised environmental concerns, as it consumes large amounts of water and outcompetes native vegetation, leading to reduced biodiversity. The plant's antimicrobial and anti-inflammatory properties have been studied for treating respiratory conditions and skin infections, and its potential applications in sustainable forestry and environmental management are ongoing.

Cymbopogon citratus (Lemongrass) and Cymbopogon nardus (Citronella Grass)

These two plants are species in the *Cymbopogon* genus, known for their aromatic properties and diverse applications in traditional medicine, culinary practices, and industry (Iwu, 1993). Lemongrass is native to tropical regions of Asia and is known for its anti-inflammatory, antipyretic, and analgesic properties. It is also used in Southeast Asian cuisine for its lemony flavor. *C. nardus*, native to tropical Asia, is used as an insect repellent and has antifungal, antibacterial, and anti-inflammatory properties. It is also used in aromatherapy for stress relief and anxiety relief. Both species have strong, citrus-like aromas, with lemongrass being more commonly used in culinary applications, particularly in Southeast Asian cuisine, and citronella being primarily used for external applications like topical treatments and insect repellents. Both species have significant medicinal uses, with lemongrass being more popular for internal use in teas and remedies, and citronella primarily used for external applications like topical treatments and insect repellents.

C. citratus and *C. nardus* are two widely used species in traditional African medicine, known for their therapeutic properties and use as antitussive agents (Kassahun et al., 2020). Lemongrass is used to prepare herbal teas or decoctions to relieve coughs, colds, and sore throats, due to its soothing and anti-inflammatory properties. It contains bioactive compounds like citral, geraniol, and myrcene, which help alleviate underlying causes of cough, such as respiratory infections and inflammation. The leaves of *C. citratus* are often boiled in water to make an infusion, which is consumed as a warm beverage. Citronella grass is also used as a natural remedy for coughs and respiratory issues, with its essential oil rich in citronellal, citronellol, and geraniol used in steam therapy to clear the airways and ease breathing. These plants are accessible, culturally relevant, and offer a natural alternative to modern medicine, particularly in regions with limited healthcare resources or preference for natural remedies.

Challenges and Opportunities in Researching African Antitussive Plants

Conservation of Medicinal Plants

The preservation of African antitussive plants faces several threats, including habitat loss, overharvesting, climate change, and invasive species. Habitat loss occurs due to deforestation, land conversion, overharvesting, and high demand. Climate change can alter the growing conditions of medicinal plants, affecting their distribution, growth, and chemical composition. Climate shifts can result in the loss of suitable habitats for medicinal plants, exacerbating the risk of extinction. Invasive species can also compete for resources, leading to declines in native plant populations and reduced biodiversity (Akerele et al., 1991).

To conserve these plants, conservation strategies include establishing protected areas, identifying biodiversity hotspots, implementing sustainable harvesting practices, establishing seed banks and botanical gardens, and developing propagation programs (Breman et al., 2021). Local communities play a crucial role in conservation efforts, including incorporating indigenous knowledge, recognizing cultural significance, participating in community-based conservation, and promoting education and awareness. Collaborative efforts with NGOs and research institutions can also enhance conservation efforts (Kadam & Pawar, 2020).

Standardization and Quality Control

Standardizing herbal preparations is a complex task due to various challenges (Kunle et al., 2012). These include genetic variability in plant material, differences in harvesting and processing techniques, complex phytochemical profiles, and interactions between compounds. The absence of standardized methods and variations in analytical equipment can also hinder consistency.

To ensure consistency and efficacy, phytochemical analysis techniques such as HPLC and GC-MS can be used to identify key active compounds (Fischer et al., 2012). Standardization of extraction processes, such as solvent selection, extraction time, and temperature, can improve consistency. Regular testing and analysis of extracts can maintain consistency.

Formulation and processing controls, such as controlled formulation and processing techniques, can also contribute to the overall efficacy and safety of herbal products. Regulatory frameworks, such as national and international standards (Wang et al., 2023), Good Manufacturing Practices (GMP) (Organization, 2007), and quality control measures, such as testing for contaminants and obtaining certification and accreditation, can enhance the credibility and reliability of herbal products (Bansal et al., 2017).

Consumer protection and education are also crucial. Clear labeling of herbal products and educational programs can promote the use of high-quality herbal products. By addressing these challenges, it is possible to produce reliable and effective antitussive products that meet high-quality standards and contribute to effective treatment options. (W. H. O., 2018).

Ethical Considerations

The ethical considerations in researching African antitussive plants involve recognizing and protecting intellectual property rights, ensuring fair benefit-sharing with indigenous communities, and practicing ethical sourcing of plant materials (Aboriginal & Studies, 2003). Intellectual property rights involve ensuring proper acknowledgment and consent from indigenous communities, while protection involves developing legal frameworks to protect indigenous knowledge from exploitation (Rimmer, 2015). Benefit-sharing agreements should ensure equitable distribution and informed consent from indigenous communities. Ethical sourcing of plant materials involves sustainable harvesting, avoiding overexploitation, and assessing the environmental impact of harvesting practices. Fair trade practices support local economies and ensure transparency in supply chains. Respecting cultural heritage and traditional knowledge involves acknowledging cultural significance, collaborating with indigenous communities, documenting and recognizing traditional practices, and following ethical research practices. Cultural appropriation involves avoiding exploitation and promoting respectful engagement with indigenous communities. By adhering to these ethical principles, researchers can contribute to the sustainable and equitable use of medicinal plants while honoring the contributions and rights of indigenous communities.

Opportunities for Research and Development

Traditional healers and scientists can collaborate to exchange knowledge about medicinal plants, enabling joint research initiatives and community-based research (Stewart et al., 2009). This approach can validate traditional claims through rigorous scientific testing and provide a deeper understanding of plant-based remedies. Participatory research methods can identify priority research areas and empower communities to be active participants in the research process. Ethical collaboration is essential, ensuring respect for traditional healers' expertise and mutual benefits.

The potential for developing new antitussive drugs from African plants includes discovering novel compounds through phytochemical screening, leading compound development, preclinical testing, and clinical trials (Biharee et al., 2024). Innovative formulations and delivery systems can enhance therapeutic efficacy and patient compliance (Balogun et al., 2023). Bioavailability optimization can also enhance the therapeutic potential of plant-derived compounds (Tan et al., 2021).

Commercialization prospects and market potential are promising, with a growing interest in herbal medicine and global market potential (Ahmad Khan & Ahmad, 2019)(82). Partnerships with pharmaceutical companies, branding, and marketing strategies can facilitate the commercialization of plant-based antitussive drugs (Chaachouay & Zidane, 2024).Compliance with regulations and navigating intellectual property rights are crucial for successful commercialization (Reichman, 2009).

Conclusion and Future Firections

Summary of Key Findings

The literature review discusses the traditional use of African antitussive plants for treating coughs and respiratory conditions. It highlights the importance of indigenous knowledge systems in identifying and applying these plants. The review identifies major classes of phytochemicals in these plants, including alkaloids, flavonoids, saponins, and terpenoids, which contribute to their antitussive properties through mechanisms like anti-inflammatory effects, bronchodilation, and mucus modulation. The review also discusses phytochemical analysis techniques and the pharmacological studies of these plants. The review also highlights case studies of notable African antitussive plants, such as Drosera madagascariensis, Eriodictyon californicum, Lannea microcarpa, and A. boonei. Challenges in researching antitussive plants include conservation, standardization, and ethical considerations. However, opportunities include collaboration between traditional and scientific communities, the potential for developing new drugs, and commercialization prospects. The review's findings have significant implications for ethnobotany and pharmacology, offering opportunities for integrat-

ing traditional knowledge with scientific advancements and enhancing public health outcomes.

Future Research Directions

Further research is needed to confirm the efficacy and safety of African antitussive plants. This includes expanding clinical trials, conducting molecular and cellular studies, and integrating interdisciplinary approaches. Long-term safety and efficacy assessments are also necessary to understand potential side effects and interactions with other medications. Molecular and cellular studies should focus on elucidating the specific mechanisms of action of bioactive compounds in antitussive plants. Molecular and proteomic analysis can provide insights into their therapeutic mechanisms and identify potential biomarkers for efficacy. Standardized protocols for extraction, formulation, and quality control should be developed.

Interdisciplinary studies, such as combining ethnobotany with genomics, pharmacogenomics, and integrating pharmacology with traditional knowledge, can enhance our understanding of plant medicinal properties. Collaborating with traditional healers to validate pharmacological findings can bridge the gap between traditional and scientific knowledge. Incorporating cultural perspectives into drug development can enhance the relevance and acceptance of plant-based treatments.

Environmental and ecological studies can address sustainability and conservation issues related to the harvesting of medicinal plants. Studying the impact of climate change on the availability and quality of medicinal plants can provide insights into how environmental changes may affect the efficacy of antitussive treatments. Future ethnobotanical surveys should include regional diversity, community engagement, focused pharmacological research, and interdisciplinary research models.

Integration of Traditional Medicine into Healthcare

Integrating antitussive plants into national healthcare systems involves several strategies. These include developing national policies that recognize and integrate traditional medicine, establishing regulatory frameworks to ensure the safety, efficacy, and quality of plant-based remedies, collaborating with healthcare providers through training and education, and promoting interdisciplinary collaboration between traditional healers and modern healthcare practitioners.

Incorporating antitussive plants into healthcare services can provide affordable, accessible treatments, especially in regions where conventional medicines may be limited. This can increase availability for underserved populations and improve health outcomes in remote or resource-limited areas.

The combination of traditional and modern treatments can offer holistic care and personalized medicine and contribute to global health impact. It can also promote sustainable practices by utilizing locally available resources and supporting sustainable harvesting practices.

The economic and social benefits of integrating antitussive plants include economic development by creating jobs and supporting local economies, and cultural preservation by recognizing indigenous knowledge and practices. By embracing both traditional and modern approaches, healthcare systems can provide comprehensive and culturally sensitive care that addresses a wide range of health needs.

Final Reflections

Preserving and promoting African medicinal plants is crucial for maintaining cultural heritage, biodiversity, and public health. Traditional knowledge plays a vital role in modern medicine by offering alternative treatments, fostering innovation, and contributing to global health solutions. It is essential to protect plant species, ensure sustainable harvesting practices, and involve local communities in conservation efforts.

Economic and health benefits are also significant, as African medicinal plants can create economic opportunities for local communities and offer effective treatments for various health conditions. Traditional knowledge can be integrated into modern medicine

through collaborative research, fostering mutual respect and understanding. Cultural sensitivity and respect are essential for ethical research and collaboration.

Ethnomedicine can address emerging health issues, such as antibiotic resistance and chronic diseases, by offering unique perspectives and remedies that may not be available through conventional medicine. Research into ethnomedicine can uncover new therapeutic agents, improve understanding of traditional practices, and validate their efficacy.

Education and advocacy efforts can raise awareness and promote the integration of traditional remedies into mainstream healthcare. Building supportive networks and partnerships can help advance the field and ensure the preservation and effective utilization of traditional knowledge. In conclusion, preserving and promoting African medicinal plants is essential for cultural heritage, biodiversity, and public health.

Author Contributions

Bertin Mikolo conceptualized the study, conducted the literature review, and drafted the manuscript. B.M. was also responsible for the analysis of the antitussive plants and their traditional uses. Pavel Ossiala contributed to the review of phytochemical data, provided guidance on the pharmacological aspects, and critically revised the manuscript for important intellectual content. Both authors reviewed and approved the final manuscript.

Conflict of Interest

Authors have no conflict of interest.

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