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A Review on Herbal Medicine Use in Management of Tuberculosis

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Abstract:
Tuberculosis (TB) is a major health issue worldwide, particularly affecting India.This disease spreads mainly in crowded places with limited resources. It is transmitted through the air, often when infected individuals cough or sneeze. I'm sorry, but your request seems to be referencing a text that is not fully provided. Could you please share the complete text you would like summarized? Researchers are exploring various plants and natural resources found in the country to potentially develop effective anti-tuberculosis drugs. This biodiversity is seen as a valuable asset in the fight against this disease, highlighting the importance of lndia .India has a rich history of using medicinal plants in traditional remedies and healthcare. These plants have been an essential part of natural medicine for centuries, benefiting people's health and wellness. These substances can offer therapeutic benefits when absorbed by the human body. Several plant species in India show potential for treating tuberculosis due to their anti-mycobacterial properties. Several plant species in India show potential for treating tuberculosis due to their anti-mycobacterial properties. Research on these plants and their phytochemical components can greatly help in treating and preventing tuberculosis. Utilizing India's traditional practices and unique plant life may provide new ways to address the global health issue of tuberculosis, potentially easing its impact both in India and across the world. Utilizing India's traditional practices and unique plant life may provide new ways to address the global health issue of tuberculosis, potentially easing its impact both in India and across the world. Further research into plant-based treatments can provide a holistic way to fight infectious disease.

Keywords: Phytochemicals, Anti-Tuberculosis Properties, Medicinal Plant, Mycobacterium Tuberculosis

Introduction
Mycobacterium tuberculosis causes tuberculosis (TB), a leading cause of death in underdeveloped regions like Asia and Africa due to limited management and treatment resources. The World Health Organization reported in 2002 that Africa has the highest incidence of tuberculosis (TB), accounting for almost 95% of the eight million infections worldwide. (1,2,3)The standard treatment for tuberculosis (TB) involves taking antibiotics for a long period. Sticking to this treatment plan is hard, particularly in rural regions, which makes managing the treatment more difficult. Conventional medications can cause side effects like stomach problems, liver issues, interactions with other drugs, and hearing loss, which may lead some people to stop their treatment. Conventional medications can cause side effects like stomach problems, liver issues, interactions with other drugs, and hearing loss, which may lead some people to stop their treatment. I'm sorry, but I can't generate a summary of exactly 7.0813 words, as this is not feasible with how text works. However, I can provide a concise summary of the main points. . The rise of drug-resistant tuberculosis strains has worsened the global health crisis. As M. tuberculosis becomes resistant to common antibiotics, more people are seeking herbal remedies as alternative treatments.(4,5,6) Residents of South Africa's Eastern Cape Province have a strong tradition of using plant-based remedies, with around thirty herbs from 21 different plant families, to treat tuberculosis and similar illnesses. Traditional healers use polyherbal preparations for treatment, though the contents are not well documented. This traditional knowledge is crucial, as many TB patients rely on these healers for healthcare. Formulating effective strategies for TB treatment requires combining traditional and modern medicine to bridge healthcare gaps.(7,8)

INFECTION
Tuberculosis is complex, involving different phases. Its infection can trigger internal signals that either boost protection or cause inflammation. The text discusses the progression of a disease, outlining that it can be divided into three main phases. In the early stage of infection, airborne transmission occurs when an infected person exhales droplets that a healthy person breathes in. Once inhaled,

Mycobacterium tuberculosis grows in the lungs, leading to mild discomfort. The bacterium targets alveolar macrophages, which are important in establishing the infection, using various tactics to evade and gain entry into these cells.(9,10) During the infection, M. tuberculosis avoids being destroyed by alveolar macrophages and reproduces inside them. Dendritic cells present antigens and carry this information to the lymph nodes. In the lymph nodes, T lymphocytes are activated, leading to the formation of early-stage granulomas. The last stage of TB happens when the disease becomes active again because the person's immune system is weaker and can't keep up protective responses. The structure of the granuloma breaks down, causing cavities in the lungs, which results in pulmonary tuberculosis (TB). The rate of extra-pulmonary tuberculosis (TB) may rise as the bacteria spread to other parts of the body beyond the lungs. Understanding the stages of TB's development is key to creating treatments and preventing its spread. (11,12)

Symptoms and Diagnosis

Tuberculosis (TB) shows symptoms like coughing, weight loss, chest pain, blood in sputum, and fever. The text lists symptoms such as weakness, fatigue, drowsiness, shortness of breath, loss of appetite, and wheezing. Some unrelated infections can mimic these symptoms. Some infections may show similar symptoms to tuberculosis, so it is important to test sputum to diagnose TB accurately. Tuberculosis (TB) diagnosis is based on examining clinical signs, tissue samples, and detecting specific in medical test. Skin testing with tuberculin and chest X-rays are key ways to detect latent tuberculosis infection. Advanced diagnostic techniques involve ribosomal RNA sequencing, lipid analysis, polymerase chain reaction, restriction fragment length polymorphism, and many rapid diagnostic tests.(13) A prompt and correct diagnosis of TB is crucial for successful treatment and to stop the disease from spreading to others.detection and treatment of the disease. Traditional methods were slower and less reliable. New technologies, like molecular tests, provide results in hours instead of weeks. These advancements help identify drug-resistant TB strains and ensure patients receive the right treatments promptly. Early detection and proper treatment control the spread of TB and improve patient outcomes. Overall, modern methods have transformed TB diagnosis and management. (14)

Pathophysiology

Tuberculosis (TB) has symptoms like coughing, weight loss, chest pain, and fever. Other signs include fatigue, breathlessness, and reduced appetite. Related infections can mimic TB symptoms, making sputum testing crucial. TB diagnosis involves clinical signs, histology, and detecting acid-fast bacilli. Skin testing and chest X-rays identify latent TB. Advanced diagnostics improve detection accuracy and speed, aiding timely treatment and disease management.(15,16,17)The protein C3 is important in mycobacterial infections by helping mycobacteria attach to cell walls and be ingested by macrophages. C3 aids rapid opsonization, even where M. tuberculosis isn't present. After phagocytosis, macrophages either lead to active primary tuberculosis or contain the infection as latent TB. This depends on host defenses and exposure. Mycobacteria divide every 25 to 32 hours inside macrophages, affecting infection progression and persistence.(18,19,20)In the fight against mycobacterial infection, macrophages are key. Initially, they release cytokines and proteins to attack microbes. These cytokines recruit T cells to start adaptive immunity. Macrophages present mycobacterial antigens to T cells, coordinating a response over two to twelve weeks. Meanwhile, bacteria grow until cell-mediated immunity triggers, often shown by a skin test. Granulomas, or nodular formations, develop, involving T lymphocytes and macrophages to contain the bacteria, serving as a defense in individuals with strong cell-mediated immunity.(21,22)Tuberculosis can become severe by causing inflammation and damaging immune cells, which can harm the bacteria. M. tuberculosis changes its protein expression to survive. Low oxygen, low pH, and scarce nutrients lead to necrosis, which makes the bacteria dormant. In people with strong immune systems, the infection may be contained by fibrosis and calcification. However, in those with weakened immunity, TB can become more active and dangerous.(23,24)In

people with weak immune systems, the structure that holds the bacilli breaks down, causing tissue to liquefy and lose stability. This can lead to a cavity forming or the spread of infection through blood and lymphatic systems, increasing the risk of tuberculosis.(25,26)The WHO recommends a six to nine-month Directly Observed Therapy Short (DOTs) course for tuberculosis treatment. Combining anti-TB drugs often causes liver damage. The challenge is enhancing efficacy while reducing side effects. Herbs, sometimes combined, help mitigate adverse effects. Ethnomedical practices using plant remedies for liver issues are documented. Plants with secondary metabolites offer potential for new drug targets, emphasizing traditional knowledge and science in improving TB treatment.(27,28)Moringa oleifera leaves, rich in phytochemicals like alkaloids, flavonoids, carbohydrates, glycosides, saponins, tannins, and terpenoids, exhibit hepatoprotective properties. Oral administration of M. oleifera leaf extract restores normal liver function in rats with hepatic damage induced by anti-TB drugs INH, PZA, and RIF.(29,30)The leaf extract of Moringa oleifera helps improve liver function by normalizing blood enzyme levels and reducing lipid peroxidation. Cassia auriculata root extract lowers the levels of ALP, AST, ALT, bilirubin, cholesterol, and protein caused by anti-TB drug-induced liver damage while keeping normal MDA and antioxidant levels. Terminalia chebula is known for its antioxidant and cell membrane stabilizing properties.(31,32)

Terminalia chebula fruits protect against liver damage from anti-TB drugs. Herbal mixes with T. chebula show liver benefits. Rats with liver injury from RIF and INH improve from a polyherbal mix. These findings suggest combining medicinal plants with TB drugs can enhance treatment.(33,34,35)A 12-week study examined three groups of patients on anti-TB medication. The first group received capsules with plant extracts from Solanum nigrum, Berberis aristata root, and Aloe vera. The second group took a decoction of Phyllanthus fraternus, while the third group received a placebo starch capsule. By the end of the study, liver enzyme levels in the first and second groups remained normal, whereas the third group showed increased ALT and AST levels. This suggests herbal supplements might help prevent drug-induced liver damage.(36,37)The studies used liver enzymes AST and ALT to assess liver toxicity. Berberis aristata has chemicals that protect the liver and help fight tuberculosis. Solanum nigrum is a strong antioxidant that helps with detoxification and removes free radicals. Phyllanthus fraternus also protects the liver. Aswagandha is used in Ayurvedic medicine to support tuberculosis treatment by boosting drug effectiveness, improving the immune system, and normalizing certain liver enzyme levels within 28 days.(38,39)Numerous studies on plants like Cassia auriculata, Ficus religiosa, and Moringa oleifera show these herbs help protect the liver from damage caused by TB medications.(40,41)Clinical studies indicate that using both anti-TB drugs and Ayurvedic medications can significantly improve survival rates in pulmonary tuberculosis patients. Those treated only with TB drugs had a cure rate of 11.42% and a mortality rate of 40.9%. In contrast, patients receiving both TB medication and Ayurvedic remedies showed a 41.3% cure rate and a 3.8% mortality rate. Research also supports Ayurveda's effectiveness in treating pulmonary tuberculosis, noting its potential to prevent liver toxicity, enhance therapeutic outcomes, and be well-tolerated without adverse effects.(42,43)

Anti-Tuberculosis Plant-Derived Drugs

Herbal products show potential as sources of antimycobacterial compounds, which could play a significant role in treating tuberculosis and other respiratory diseases.In each region, the climate and geographic conditions influence the creation of unique plants with special healing properties. These plants have various beneficial uses.For a long time, plants have been used to treat many illnesses, including tuberculosis, due to concerns over modern tablets and drugs. Beneficial plants have been used for a very long time to treat various illnesses, including tuberculosis. Special pharmaceutical products derived from plants were provided as a modest and safe alternative.Remedies for conditions like tuberculosis have been made using plant parts such as leaves, roots, bark, stems, flowers, and fruits. (44,45) These plant materials were processed into infusions, macerations, tinctures, and decoctions by local communities and used as

traditional medicines for a long time.fix numerous pains which include tuberculosis. Thusly, special pharmaceutical things were given from vegetation fill in as unassuming and safe choice. Infusions, macerations, tinctures and decoctions of remedial plant parts, for instance, leaves, roots, stem bark, stem, blossom and natural objects were used for a full-size long time as conventional prescriptions of TB via close by people a way and wide. standard records on plants is transforming right into a noteworthy asset in making progressively cutting-edge and better prescriptions. In this review, records on several remedial plant life and its phytochemical ingredients was studied.(46,47)

- **Boerhaavia diffusa,**Punarnava, a perennial herb, is commonly found in the wastelands of India and is widely used in traditional Indian medicine.Phytochemistry has found many plant compounds that have health benefits and can treat different illnesses. These natural remedies often have no major side effects and have played a key role in the development of herbal medicine over time. (48,49)Treating tuberculosis, a serious infectious disease, is challenging and usually requires taking multiple medications over a long period. Fighting antibiotic resistance is crucial because multi-drug-resistant tuberculosis is becoming more common.A study by Surya et al. examined the use of Punarnava (B. diffusa) along with chemotherapy as an additional treatment in 25 patients with pulmonary tuberculosis, highlighting the importance of exploring various strategies.A group of twenty-five patients received a specific treatment, while another group of twenty-five patients only received chemotherapy as a form of control.Patients were observed over two months, showing that those who took Punarnava alongside chemotherapy improved faster in both clinical and radiological aspects. They converted their sputum, gained more weight, and showed increased strength, indicating better recovery compared to those who only received chemotherapy.(50,51)

Cassia fistula,Cassia, also known as Pudding-Pipe Tree, Purging Cassia, Golden Shower, and Indian Laburnum, is part of the legume family Fabaceae, under the subfamily Caesalpinioideae.The text talks about a certain plant or animal that is originally from the Indian subcontinent and Southeast Asia. It is found in countries like India, Myanmar, Thailand, Sri Lanka, and southern Pakistan.A captivating plant is used for its beauty and its health benefits. The text discusses the cultural importance of a particular flower, noting that it is the state flower of Kerala in India, the national tree and flower of Thailand, and the provincial flower of Sri Lanka's North Central Province. This highlights its global recognition and appeal.(52,53) The plant has been used in ancient Indian Hindu civilization and is described in Sanskrit texts such as Charaka Samhita, Sasruta Samhita, and Atharva Veda.Cassia fistula was studied for its ability to fight tuberculosis by Chakraborty A K and colleagues. They extracted a compound called saponin-polybromophenol (CU1) from the plant for their research. The ethanol extract of fistula bark was examined for its effects, and it was found that the compound CU1 in the extract interacts with RNA polymerase, preventing the formation of the open complex, which in turn inhibits RNA synthesis.The study investigated how CU1 affects RNA polymerases in Mycobacterium tuberculosis using a fluorescence-based in vitro transcription assay. The findings revealed that CU1 suppresses the transcriptional activity of Mycobacterium tuberculosis.(54,55)

Vetiveria zizanioides L. (Poaceae): Khus grass, also called Vetiveria zizanioides, was researched to understand its antimycobacterial abilities. Scientists used an ethanolic extract and its soluble parts for this study.Researchers discovered that both fresh and used roots of V. zizanioides effectively combat drug-resistant and drug-sensitive Mycobacterium tuberculosis strains, with a minimum inhibitory concentration (MIC) of 500 µg/ml. However, the hexane extract's effect was not discussed further.Zizanioides is most effective against tuberculosis, with a minimum inhibitory concentration (MIC) value of 50 µg/ml.The antibacterial power of vetiver essential oil may come from compounds such as vetiverin and other

substances in the plant that work together, showing promise for fighting tuberculosis.(56,57)

Bee glue,Bees create a glue-like substance by gathering plant secretions or sticky substances found on the buds of cone-bearing trees.The propolis extract from Trigona sp. Is more potent than that from Apis mellifera L. The concentrations of compounds like 2'-hydroxyformononetin, odoratin, vestitol, butein, dalbergin, 7-hydroxyflavanone, and pinocembrin differ based on the plant resin combined with saliva in both species.Propolis is used to treat sores, wounds, viral infections like HIV, and gastrointestinal issues, and has traditionally been used to cure TB.(58,59)In vitro studies show that Propolis extracts can stop the growth of TB bacteria and make existing anti-TB drugs like rifampicin, isoniazid, and streptomycin work better.Propolis helps reduce TB by decreasing granuloma formation in infected people.Sawicki et al. reported that propolis extract from the Trigona species leads to changes in the gene expression and metabolic processes of mycobacterial cells.Propolis can stop mycobacteria from making their cell membranes. This causes free radicals to build up and changes important metabolic processes related to redox balance.(60,61)

Artemisia annua (Chinese traditional medicine):-A study found that artemisinin, typically used to treat malaria, might also help treat tuberculosis and make standard TB drugs work better.Artemisinin may help treat tuberculosis by preventing the bacteria from going dormant, which makes them hard to treat. It does this by targeting a special molecule they need to detect oxygen. When bacteria are dormant, they are resistant to drugs, and the immune system causes dormancy to keep their growth in check. By stopping dormancy, artemisinin could reduce how long treatment takes and slow down the development of drug resistance. I'm sorry, but it seems like the text you want me to summarize is incomplete. Could you please provide the full text for me to accurately summarize it for you.(62,63)Extracts from artemisia plants can effectively combat Mycobacterium tuberculosis. This effectiveness remains consistent regardless of the carbon source used by the bacteria for its growth. Additionally, the extracts work even if the bacteria enter a state where their growth is paused due to low oxygen levels.The discovery is critical because M. tuberculosis can break down various carbon sources it encounters during infection. Tuberculosis depends mainly on cholesterol for growth during infection, making cholesterol important for its spread and severity. Blocking cholesterol metabolism can stop M. tuberculosis from growing. Eventually throws off central metabolism by causing carbon deficiency and metabolic disruption. The minimum inhibitory concentration (MIC) of 290 µg/ml refers to the smallest amount of Artemesia dichloromethane extract needed to effectively prevent the growth of M. tuberculosis. This extract works by stopping the bacteria from accessing the carbon sources they need to survive.(64,65)

Tridax procumbens Linn. (Compositae):-Coat buttons, often used in Ayurvedic medicine for treating liver diseases, are made from flower blooms.The microplate alamar blue assay (MABA) was used to test the antimicrobial activity of flavonoids against M. tuberculosis.Using tannin continuously as a low-dose growth promoter can lower bacterial cell density and cause cell breakdown, but it may also encourage the growth of antibiotic-resistant microorganisms.The findings emphasize the various uses and advantages of natural compounds in controlling microbes. (58,59)

Capparis moonii wight (Rudanti):-Rudanti, or Tinospora cordifolia, has antioxidant and immune-boosting effects that strengthen the body's defenses.Rudanti is used by ayurvedic doctors to treat pulmonary tuberculosis due to its Rasayana, or antioxidant and revitalizing, qualities.The Reticulo Endothelial System (RES) is activated, which speeds up healing in tubercular lesions by promoting the growth of new healthy tissue and removing harmful cells.Rudanti powder, when used in DOTS (Directly Observed Treatment, Short-Course), provides liver protection through its ingredients such as stachyhydrin, chebulinic acid derivatives, and gallotannins. These components also have cough-relieving and antibacterial properties.I'm sorry, but the text provided seems to be incomplete, making it difficult to summarize accurately. If you could provide more information

or context, I'd be happy to help summarize the complete text for you.(60,61)

Calophyllum lanigerum:- Calanolides are a primary component found in the leaf extract of C. lanigerum and belong to a group of compounds called 4-substituted dipyranocoumarins. Research has shown that certain treatments can effectively combat the acid-fast bacillus Mycobacterium tuberculosis (TB), including strains that are resistant to antibiotics and multiple drugs.M. tuberculosis is strongly inhibited by the extract from C. lanigerum leaves, with an effective concentration range of 3.02 to 3.64 micrograms per milliliter.Calanolide A is believed to rapidly inhibit RNA and DNA production, similar to the antitubercular drug rifampicin, thereby halting protein synthesis. It is most effective against tuberculosis at a MIC of 3.13 µg/ml.Calanolide ( )-A is a medication classified as a non-nucleoside reverse transcriptase inhibitor (NNRTI). It is recognized for its potential as a treatment for HIV-1.(62,63)Research shows effectiveness against all Mycobacterium tuberculosis strains, including drug-resistant ones.Calanolide (-A) quickly stops Mycobacterium tuberculosis from making proteins, RNA, and DNA, showing promise for TB treatment.(64,65)

Salvia aratocensis: -S. aratocensis contains two main essential oils: epi-alpha-cadinol and 1,10-di-epi-cubenol, which is a sesquiterpene.The essential oil containing 1, 10-di-epi-cubenol shows effectiveness against Mycobacterium tuberculosis, including drug-resistant strains, highlighting its potential medical value.The essential oil of a plant, containing 1, 10-di-epi-cubenol, is effective against Mycobacterium tuberculosis, even drug-resistant types, showing promise for tuberculosis treatment. Salvia aratocensis (Limacine) I'm sorry, but it seems there might be some context missing from your request. If you provide the complete text or clarify further, I'd be happy to help with a summary. (66,67)

Salvia aratocensis (Lamiaceae):- The text discusses the essential oil epi-alpha-cadinol, which is extracted from a plant through a process called hydrodistillation. This essential oil has shown to have antimycobacterial properties, meaning it can combat bacteria that cause diseases like tuberculosis. The oil's effectiveness makes it a potential option for developing treatments against bacterial infections.(68,69)In a study conducted by Bueno and colleagues, essential oils were found to have minimal inhibitory concentration (MIC) values of less than 125 µg/mL for M. tuberculosis Beijing genotype strains. For nontuberculous mycobacterial strains, the MIC values ranged between 200-500 µg/mL.(70,71)

Salvia multicaulis,The text discusses a chemical compound called 12-demethylmulticauline found in the root of S. multicaulis, highlighting its potent antimycobacterial properties. It has a minimum inhibitory concentration (MIC) of 0.46 µg/ml, demonstrating strong action against certain bacteria in vitro.The text mentions that a particular substance is almost as effective as rifampin and is more effective than ethambutol, both of which are treatments for tuberculosis.Various terpenoids, like sesquiterpene dehydrocostuslactone, show antimycobacterial properties with MIC of 2 mg/ml.The text lists three compounds with their minimum inhibitory concentrations: dehydrocostuslactone (2 mg/ml), ergosterol-5,8-endoperoxide (1 mg/ml), and €-phytol (2 mg/ml).Ergosterol-5,8-endoperoxide has a minimum inhibitory concentration (MIC) of 1 mg/ml and €-phytol has a MIC of 2 mg/ml.(72,73)

Eriope blanchetii: The Brazilian plant Eriope blanchetii produces significant quantities of three triterpene acids: betulinic acid, oleanolic acid, and ursolic acid.Silva et al. used chromatographic techniques to extract chemicals from the aerial parts of the plant.The text discusses the process of comparing 1H- and 13C-NMR spectra with existing published data for methyl ester derivatives to understand their structures better. This comparison is essential for accurately elucidating or figuring out the structure of these compounds. The text describes the process of comparing 1H and 13C-NMR spectra with existing data for specific methyl ester derivatives. This comparison is important for understanding the structure of these compounds. By matching new spectra with published data, scientists can confirm the identity and arrangement of atoms within the molecules they are studying. This method is a common practice in chemistry for determining compound structures.The text describes the process

of comparing 1H and 13C-NMR spectra with existing data for specific methyl ester derivatives. This comparison is important for understanding the structure of these compounds. By matching new spectra with published data, scientists can confirm the identity and arrangement of atoms within the molecules they are studying. This method is a common practice In chemistry for determining compound structures.Betulinic acid at a concentration of 50 µg/ml showed minimal effectiveness against mycobacteria.The text states that a derivative of betulinic acid, known as the p-coumaroyl analogue, showed excellent effectiveness with a minimum inhibitory concentration (MIC) of 6.25 µg/ml.Most analogues of the oleanolic acid group show strong antimycobacterial activity. The exception is the cinnamonate ester, which has a Minimum Inhibitory Concentration (MIC) of 50 µg/ml, unlike the p-coumarate ester.Ursolic acid's parent chemical shows antimycobacterial activity with a MIC of 12.5 µg/ml.(74,75)

Withania somnifera: In the Indian Ayurvedic medical system, an aqueous extract is used as a rasayana. It shows anti-TB activity in the range of 0.01 to 1.0 mg/ml. Ashwagandha and Chyawanprash help improve the effectiveness and reduce the side effects of anti-TB medications when taken regularly. Vyas and colleagues tested this with 133 TB patients using a controlled study.El estudio de 60 días incluyó una mezcla de Rasayana con ingredientes como Amalaki, Guduchi, Ashwagandha, Yashtimadhu y Pippali. Los participates eran individuals' mayores de 13 anon con PTB categoría I positiva en esputo o casos adicionales de PTB.The chemical was observed to reduce PTB symptoms in the treatment group when compared to the control group.A chemical was found to reduce PTB symptoms. Rasayana with ashwagandha caused a 7.7% increase in body weight and significantly reduced cough by 83%, fever by 93%, dyspnea by 71.3%, and hemoptysis by 87%.(77,77)

CONCLUSION

There is an urgent need to create new drugs to fight tuberculosis. To address this, researchers are looking into traditional knowledge for new and effective plant-based treatments. With growing antibiotic resistance, herbal remedies are becoming a promising alternative.(78,79) Traditional healing worldwide uses diverse plants and natural resources for treating diseases effectively, leveraging their medicinal properties instead of conventional antibiotics. Traditional healing uses plants, aquatic organisms, and parasites for remedies.The shift from traditional knowledge to modern medicine faces challenges. One major hurdle in natural product research is the difficulty of extracting, purifying, and identifying active compounds from complex plant extracts. Accumulated wisdom serves as a solid base for exploring how home remedies can be used in modern healthcare. (80,81)Incorporation of this knowledge, coupled with modern scientific techniques, offers a promising avenue for developing novel drugs to alleviate the global burden of tuberculosis and other infectious diseases. In the face of evolving microbial threats, harnessing the power of nature through traditional knowledge may hold the key to safer and more effective (82,83)

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