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HERBAL MEDICINE USED IN TREATMENT OF TUBERCULOSIS: A REVIEW

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Abstract
Tuberculosis (TB) is an airborne infection that primarily affects the lungs and poses significant risks to individuals with weakened immune systems or other health issues. The use of allopathic medications for TB can lead to the development of cross-resistance or multidrug resistance, complicating treatment efforts. In contrast, herbal remedies have shown promise in treating TB due to their effectiveness and interaction with the body's natural processes. Recent research indicates that Ayurvedic medicines can significantly reduce mortality rates in TB patients, offering a lower toxicity and fewer side effects compared to conventional allopathic treatments. This review aims to explore anti-tubercular medicinal plants based on scientific literature, focusing on their chemical components and therapeutic properties against TB.

Keywords: *Tuberculosis; Herbal Medicine; Chemotherapy; Adjuvant*

Introduction
As an endemic ailment of the urban poor in the 19th and early 20th centuries, tuberculosis sparked great public concern (1). As per the World Health Organization (WHO) (2), tuberculosis (TB) (2) is a bacterial infection produced by Mycobacterium tuberculosis (1) that very usually attacks the lungs. The infection is conveyed through people to people by wet particles from both lungs and throats of persons who have prevalent respiratory diseases (3).

Epidemiology
Tuberculosis (TB) spread globally as Homo sapiens migrated from Eastern Africa, facilitated by open trade routes and increased population density. Annually, nearly ten million new cases of active TB are reported, resulting in over 1.3 million deaths. (4) Throughout history, many nations developed traditional remedies for TB as it spread, reflected in the ancient medical records of Traditional Chinese Medicine (TCM), Ayurveda, and Traditional African Medicine (TAM). This extensive historical context, spanning over 70,000 years, has contributed to a rich source of potential new treatments derived from active compounds or semi-metabolites found in these traditional medical systems. (4)

Tuberculosis in India
The Indian government now claims that the overall number of persons infected with tuberculosis has increased from 2.2 million to 2.6 million, based on examinations of medicine sales. India's Ministry of Health and Family Welfare said on World TB Day, March 24, 2019, that 2.15 million new tuberculosis cases were diagnosed in 2018. Current TB treatment, Program support the particular effects of each bactericidal agent govern the rational usage of antituberculosis treatments. Isoniazid is particularly effective against big cavities, although it also has limited efficacy in caseous lesions and macrophages (5). Rifampin is effective against the intermittently increasing population in caseous lesions and is active in all populations. 86 Streptomycin is only effective against the extracellular population, but PZA is only active in an acidic environment and has a particular effect on macrophages

(5). PZA produces its maximal impact only within the first few months of medication, according to clinical trials (2).

In India, the Revised National TB Control Programme (RNTCP) is an officially backed TB management programme that controls TB in the community (6). Despite the fact that it is a government-sponsored programme with treatment and diagnostic services for free, many still flocks to private physicians when they have a symptom. According to investigations (4), 50-80 percent of TB patients seek treatment from private practitioners. Ayurvedic medications are currently not included in the RNTCP (7). Private practitioners, including general practitioners and chest specialists, employ a variety of Ayurvedic remedies to help in TB care.

Severe side effects of exiting anti-TB Drugs

Antituberculosis drugs can cause hematological reactions, gastrointestinal intolerance, hepatitis, renal failure, and dermatological reactions. These unfavorable repercussions should be discovered soon in order to decrease linked illness and death (2).

Rifampin has following few of the most dangerous adverse effects include hemolysis, thrombocytopenia, and kidney failure (Fig. 1) (5). Anti-rifampin antibodies are absorbed by platelets, causing thrombocytopenia, which leads to platelet loss after complement fixing. PAS has so many gastrointestinal side effects that it is no longer prescribed to adults as a primary medicine (5). The liver damage caused by isoniazid and rifampin seems to be supplementary (Fig. 1). Because they are not synergistic, neither one nor the other should be given to individuals even without liver disease who are alcoholics. Retrobulbar neuritis is the most serious adverse effect of ethambutol (Fig. 1). Patients taking Dilantin and isoniazid must be advised regarding the danger of Dilantin over dosage since isoniazid is seen to hamper the metabolism of diphenylhydantoin (8).

Table 1 A possible adverse effect associated with anti-TB Chemotherapy

Chemotherapeutic agents	Adverse Effects
Streptomycin	Renal damage, Vestibular and Auditory nerve damage,
Isoniazid	Hepatitis
Rifampicin	Thrombocytopenia, Pain, Vomiting, Nausea, Hepatitis
Pyrazinamide	Arthralgia, Hepatitis
Ethambutol	Neuritis, Color blindness
Cycloserine	Convulsions, Dizziness, Depression, Psychotic Reactions
Ethionamide	Diarrhoea, Abdominal pain, Hepatotoxicity
Kanamycin	Vertigo, Auditory nerve damage, Nephrotoxicity
Thioacetazone	Skin rash, Exfoliative dermatitis

Ayurvedic approach in tuberculosis

In Ayurveda, Pulmonary Tuberculosis (PTB) is often associated with Rajayakshma, a condition primarily driven by Dhatukshaya, the depletion of bodily tissues.(4) This depletion marks the initial phase of Rajayakshma's pathogenesis. As the disease progresses, there is a loss of vital tissues, including rasa (tissue fluid), mamsa (muscle), rakta (blood), sukra (reproductive tissue), and meda (adipose tissue), leading to metabolic dysfunction known as

Dhatwagninasana.(6) This metabolic disruption ultimately results in a decline in immunity, or ojokshaya, over time. Additionally, a specific metabolic shift called Pratilomakshaya occurs, causing damage across various tissues, from sukra and meda dhatus to rasa dhatu, as per Ayurvedic principles. (7)

In the search for anti-TB compounds, bioactivity-guided fractionation has been a key method, focusing on identifying bioactive substances from medicinal plants. This approach contrasts with conventional drug development, which often involves screening extensive molecular libraries and utilizing cheminformatics for in silico analysis. The process includes isolating active compounds from essential plant parts, followed by fractionation and characterization using techniques like infrared spectroscopy, NMR spectroscopy, and mass spectrometry.(4) The bioactivities of these compounds were then tested against a range of mycobacteria. Notably, various research groups have identified numerous natural anti-TB compounds from different sources. In 2007, Copp and Pearce compiled a list of secondary metabolites from terrestrial and marine sources, animals, and microbes, which were found to inhibit TB or similar organisms. (4)

Herbal medicine

India has one of the world's most extensive plant-based medicinal traditions. In India, there are an predictable 25,000 efficient herbal-centre medicines that are utilised in religious remedy and are known to rural populations (9).
Over 1.5 million people practise traditional medicine, which uses medicinal herbs for preventative, promotional, and curative purposes. India is expected to have about 7800 medical medicine production plants, which utilise over 2000 tonnes of herbs each year (9). The creation of effective therapeutic medicines relies heavily on medicinal plants. Approximately 100 novel herbal-based medications were released into the American drug market between 1950 and 1970, deserpidine, reserpine, vinblastine, vincristine and reseinnamine are only a few examples of compounds originating from higher plants (10). Between 1971 and 1990, novel medications such as ectoposide, artemisinin, teniposide, eguggulsterone, plaunotol, lectinan, nabilone and ginkgolides were established over the universe. Paciltaxel, toptecan, gomishin, irinotecan, and other drugs were introduced between 1991 and 1995, accounting for 2% of all prescriptions. Serpentine, for example, was found in 1953 in the root of the plant Rauwolfia serpentina and was found to be a game-changer in therapy of high blood pressure. Vinblastine (9) is a drug that comes from the Catharanthusrosesus plant that is used to treat Hodgkins lymphoma, non-Hodgkins lymphomas, paediatricleukaemia, testicular cancer, choriocarcinoma and neck melanoma as vincristine is a kind of vitamin C (9). Acute lymphocytic leukaemia in children, advanced Hodgkins's disease, lymophosarcoma, cervical cancer, and breast cancer are all possible causes (10). Phophyllotoxin is a substance found in the Phodophyllumemodi plant that is currently used to treat testicular cancer, minor lung tumor, and lymphomas. Herbal derivative drugs are used to treat skin diseases, jaundice, psychological illness, high blood pressure, tuberculosis, malignance and diabetes. The creation of effective therapeutic medicines relies heavily on medicinal plants.
contemporary medicine as a result of folklore or traditional medicine's utilisation of plant material as an indigenous treatment.

Ayurvedic approach for treating tuberculosis and its symptoms with herbal medicines

Herbal products are moreover a promising wellspring of antimycobacterial mixes, which may also have colossal work inside the chemotherapy of TB and other breathing tract sicknesses. In each region, considering the climatic and geographic conditions, extra special remedial floras create and a vital wide variety of them have top notch beneficial properties [11]. On account of the adversarial impacts of cutting edge tablets and medications, plants had been an ordinary valuable asset of medicaments inside the cure of a wide volume of ailments [12, 13]. Helpful vegetation were being applied for a extreme long an ideal opportunity to fix numerous pains which include tuberculosis. Thusly, special pharmaceutical things were given from vegetation fill in as unassuming and safe choice [14]. 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 ways and wide [15, 16]. The standard records on plants is transforming right into a noteworthy asset in making progressively cutting-edge and better prescriptions [17].

1. **ASHWAGANDHA**

Ashwagandha is a common name of the herbal plant medicine ashwagandha. Its Botanical name is ***Withania Somnifera*** & it belongs to the family ***Solanaceae***

It has chemical constituents like Alkaloids , Saponins , Steroidal Lactones, Withaferin A , Withanone. It is used in the treatment of Arthritic diseases, Asthma, Cancer, diabetes, Hypertension . It has also medicinal use like Herb that boosts immunity by acting on the nervous and respiratory systems. It has wonderful wound healing effects, as well as anti-inflammatory and rejuvenating characteristics. It treats tuberculosis symptoms such as cough, cold, and bronchitis.

2. **ADULSA**

Adulsa is a common name of the medicinal herbal plant Adulsa . Its Botanical name is ***Justicia vasica*** & it belongs to the family ***Acanthaceae.***

It has chemical constituents like Adhatodine, Anisotine, Sicinolone, Vasicine, Vasicinone, Vasicoline, Vasicolinone. It is used in the treatment of Coughs, chronic bronchitis, asthma, colds, antispasmodic, and bronchitis disorders. It has also medicinal use like Antibiotic, Antibacterial, Antisclerostin, Anticoagulant (18)

3. **BRAHMI**

Brahmi is a common name of the medicinal herbal plant Brahmi . Its Botanical name is ***Bacopa monnieri*** & it belongs to the family ***Plantaginaceae*** (18)

It has chemical constituents like Brahmine Herpestine, Nicotine, D-Mannitol, Hersaponin, Monnierin, Bacosides A, Bacosides B. It is used in the treatment of Alzheimer's disease, Antibacterial, Antifungal, Improving memory, Anxiety, Attention Deficit. It has also medicinal use like Acts on the respiratory, neurological, digestive, circulatory, and excretory systems. It has a number of therapeutic properties, including rejuvenating properties, and can be used to treat colds and coughs, as well as other common symptoms.

4. TULSI

Tulsi is a common name of the medicinal herbal plant Tulsi . Its Botanical name is ***Ocimum tenuiflorum*** & it belongs to the family ***Lamiaceae*** **(18)**

It has chemical constituents like Essential oil consists mostly: Eugenol (~70%) β-elemene, Caryophyllene, Germacrene, Isothymusine, β-bisabolene , 1,8-cineole, Methyl chavicol. It is used in the treatment of bronchitis, bronchial asthma, malaria, diarrhea, dysentery, skin diseases, arthritis, painful eye diseases, chronic fever, insect bite etc. (10). It has also medicinal use like Adaptogenic, Analgesic, Antiasthmatic, Anticancer, Antidiabetic, Antiemetic, Antifertility, Antifungal, Antimicrobial, Antispasmodic, Cardioprotective, Hepatoprotective.

5. ALOVERA

Alovera is a common name of the medicinal herbal plant Alovera . Its Botanical name is **Aloe barbadensis** & it belongs to the family **Liliaceae (6).**

It has chemical constituents like Anthraquinone glycosides: Emodin, Barbaloin; Galacturonic acid, Vitamins, Enzymes, Minerals, Sugars, Lignin, Saponins, Salicylic Acids (12). It has also medicinal use like Antibacterial, Antiviral, Antiseptic, Antiinflammatory, Laxative, Antitumor, Purgative, Anti-oxidative. Active components in anthraquinone glycosides have anti-tubercular properties.

6. GARLIC

Garlic *(Lahsun)*is a common name of the medicinal herbal plant Garlic . Its Botanical name is ***Allium sativum*** & it belongs to the family ***Amaryllidaceae.***

It has chemical constituents like Aliin, Allicin, E-Ajoene, Allylpropyl Disulfide, Diallyl Trisulfide, Sallylcysteine, Vinyldithiines, Allylmercaptocyste in, Several enzymes (18). It has also medicinal use like Antioxidant, Antithromboti c, Antihypertens ive Antimutagenic , Anticarcinoge nic Antiviral, Antifungal, Antiparasitic, Antidiabetic, Immunomodulatory, Hypolipidemic.

Garlic has incredible antioxidant, bacteriostatic, and antifungal capabilities, as well as the ability to treat stomach disorders. It is essential in the treatment of several common Tuberculosis symptoms, such as cough, cold & others (18)

7. AMLA

Amla (Amalaki) is a common name of the medicinal herbal plant Amla . Its Botanical name is ***Phyllanthus emblica*** & it belongs to the family ***Phyllanthaceae. (19)***

It has chemical constituents like Ascorbic acid, Ellagic acid, Chebulinic acid, Gallic acid, Chebulagic acid, Apeigenin, Quercetin (19). It has also medicinal use like Antioxidant, Hepatoprotective Cardioprotective Immuno-modulatory, Hypolipedemic, Anticancer, Antidiabetic, Antidepressant, Antiulcerogenic, Insecticidal, Larvicidal.

Patients' immunity is boosted, and their digestion is improved; they also have a strong antibacterial activity. It's available as syrups, amla juice, chewing tablets.

8. TURMERIC

Turmeric One more expected natural medication for tuberculosis is turmeric. In the lab examination named, Curcumin might assist with conquering drug-safe tuberculosis, the analysts found that curcumin (which you can track down in turmeric), regulated the resistant reaction to Mycobacterium tuberculosis.
The report made sense of that curcumin had the option to eliminate TB microorganisms from the deliberately tainted cells in culture. At the point when the scientists looked nearer, they found that curcumin invigorated the macrophages, a sort of white platelet that encompasses and kills microorganisms.

CONCLUSION

The urgent need for developing new medications to reduce the global burden of tuberculosis (TB) has greatly stimulated the exploration of traditional knowledge as a source for discovering novel and effective phytotherapeutic agents. Herbal sources are proving to be highly effective, offering significant antimicrobial activity against a wide range of microorganisms and possessing a rich chemical diversity. Across the globe, numerous plant species have been, and continue to be, utilized in various traditional healing systems, along with marine organisms and fungi, providing an almost limitless source of bioactive compounds. However, the discovery and development of new natural products often involve the challenging processes of isolating, purifying, and identifying target compounds from complex raw extracts. Recent research has highlighted the importance of plant extracts in controlling harmful strains of Mycobacterium tuberculosis, which pose a significant threat to human health, and in the development of safer and more effective therapeutic drugs.

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