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MEDICINAL PLANTS OF UTTARAKHAND (INDIA) AND THEIR BENEFITS IN THE TREATMENT OF TUBERCULOSIS: CURRENT PERSPECTIVES

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ABSTRACT
Tuberculosis (TB) is an extremely contagious disease proclaimed a worldwide health crisis by the World Health Organization (WHO), around tierce of the globe inhabitants being contaminated with *Mycobacterium tuberculosis*. The therapy of Tuberculosis involves a continuation phase and an intensive phase. Regrettably, the emergence of multi-drug resistant tuberculosis, majorly because of less cohesion to advised therapies or incompetent health maintenance structures, necessitate anyhow 20 months of therapy with less effectual, more lethal drugs, *i.e*., amikacin, fluoroquinolones, capreomycin, and kanamycin. Hence, there exists a crucial necessity for the determination and evolution of novel drug to decrease global load of this infectious disease. There has been investigation on plant-based medicines but have not concentrated all that greatly on indigenous plant varieties of Uttarakhand region. The discovery of anti-TB drug from plants may conclude in the invention of crude extracts which can be utilized as an effective TB drug. Apart from their antitubercular property, herbal compounds can be functional in ancillary treatment to upgrade the potency of standard antitubercular remedies, to reduce their harmful outcome and to alter multi-drug resistance problem because of the environment pliability and genetic flexibility of *Mycobacterium*.

KEYWORDS: Medicinal plant, crude extract, antitubercular property, *M. tuberculosis*.

INTRODUCTION

Tuberculosis is one of the former terminator diseases of humankind. It is an airborne contagious illness resulted by the transference of aerosolized driblets of *M. tuberculosis* which mainly targets the lungs, producing pulmonary and lung tuberculosis. Even with the accessibility of effectual anti-tuberculosis therapy for over last 60 years, TB remains an utmost world health issue chiefly in Asian and African continents, likely because of the inadequate method for its therapy. Tuberculosis contaminate 9 million individuals mainly children each year with approximately deaths of 2 million population yearly (Adnan, 2019; Sabran, 2016; Adaikkappan, 2012).

Although, this complication has become severe as *M. tuberculosis* initiate resistance in case of both line of drugs. Because of that, there is the development of extensively-drug resistant (XDR) and multi-drug resistant (MDR) strains of *M. tuberculosis* across the globe including India (Gupta, 2010). In 2013, WHO approximated that worldwide, there were about 9 million cases of tuberculosis with 1.5 million of casualty, 360,000 out of them were infected from TB human immunodeficiency virus (HIV). In year 2015, The number of deceases increased to 1.4 million with 0.4 million of HIV-TB cases. In 2018, around 10.0 million persons fell sick with 1.2 million demise between HIV-negative and in addition, 251000 demises amid HIV-positive individuals. The eight countries responsible for two thirds of the major world TB cases are: India (27%), Bangladesh (4%), Pakistan (6%), South Africa (3%), Nigeria (4%), Indonesia (8%), The Philippines (6%), and China (9%) (Fauziyah, 2017; Gupta, 2017; WHO, 2019).

The WHO determined that around 80% of globe residents depends majorly on conventional system of medication, mainly plant-based drugs. The extracts of higher plant varieties are rising source of new anti-TB medication. India is one among the few developing nations across the worldwide which has distinctive prosperity and extensive conventional knowledge of curative plants for the cure of several diseases. This is accurate as societies all over the globe have been assembling indigenous information over generation and centuries on therapeutic utilization of plants (De silva, 1997; Jetan, 2010). Thailand, Sri Lanka, India, Cuba, China and some other nations have recommended the formal utilization of conventional structure of medication in

their Fitness Protection Plan. For instance, the Indian medicinal structure of Unani, Ayurveda, Sindha, and homeopathy to certain degree, rely on herb matter or their products for serving various individual illness (Prajapati, 2003). Karki (1999) evaluated that around 35 to 70,000 plant species are utilized at different hour or the other in sole tradition or another for curative reasons in the sphere. At the minimum, 6,500 kinds are applied in Asia solely as residence medication for different disorders. According to Anonymous, 1997, the Indian Systems of Medicine (ISM), the earliest medication operations well familiar to the globe, and obtain major composition from the plant extracts and herbs that are present in the woodland (25% from temperate forests, 75% from tropical). Singh (2016) determined that the plants have everlasting capability to generate secondary metabolites like phenols, glycosides, alkaloids, terpenoids, and tannins which have been reported to have antimicrobial activities. Natives of remote and rural areas are still depending on plants as a main constituent of their health maintenance systems as they lack approach to latest medicine services or are impotent to afford medicine due to their overprices. Indigenous medicines give rise to substantial economic welfare to local persons. The WHO declared that around 25% of present-time medication are procured from plant origin, and investigation on herbal plants of medicinal value leads to the invention of 75% of novel vegetal drugs. Locals procured knowledge regarding the therapeutic properties and economic merit of various plants through error, trial, observations, and need and the passed-on experience of seniors. Inhabitants commonly use local curative plants without earlier guidance of local healer because they are utilizing these plants since ages. This information may be proceeding secretively or inherited. However, knowledge of these treasurable plants is often restrained within lineages or in other ways, make certain that the younger generation in these localities obtain this knowledge is crucial to its progression in sustainability and use (Singh, 2019).

Medicinal plants have been employed for centenary to heal several ailments including tuberculosis. Decoctions, infusion, maceration, tinctures of different parts of the plants such as leaves, root, stem, flower, bark, and fruit have been utilized for generation as conventional cure of TB by indigenous population globally (Sharifi-Rad, 2017). The state of Uttarakhand is positioned in the northern region of India. It is a residence for diversity of flora and fauna. In spite of the enormous medicinal plant-based research, literature survey determined that a very few research works have been reported and published by different researcher for tuberculosis while using the plants from this region. So, through this review we want to highlight the importance of medicinal plants of Uttarakhand with their anti-tubercular property.

Indigenous knowledge on Tuberculosis

TB is supposed to be an infective problem that transferred majorly via sharing eating-utensils, droplet, and food of diseased person. Symptoms comprises of weight loss, cough, wheezing cough, and laboured breathing. Although, few of these symptoms may be associated to other diseases like cancer, ordinary cough and asthma but not to TB. In Indian conventional medication structure, TB is appropriately mentioned as Rajayakshma, an illness of poor prognostic, accompanying marasmus and ascites, that transfer to each other (Jayana) such as the birds flight. It results in loss of tissue (Dhatukshaya) included in pathologic process along with dysfunction of metabolism (Dhatwagninasana): generative tissue, blood, muscle, adipose tissue, and fluid are lost which give rise to lowering of immune response (Sharifi-Rad, 2017).

Tuberculosis infection

TB infection take place by bacterium engulfment by alveolar macrophages, where bacilli avoid killing and carry on to proliferate by evading the fusion of phagosome-lysosome. Supplementary macrophages and remaining immune cells then become confined to the infection site generating a directed cellular structure called as granuloma. In granuloma, although vigorously replicating bacilli are established, non-replicating persistent (NRP) (dormant) form of Mtb can also be found which are persuaded by the environmental factors. The NRP condition of Mtb is distinguished by the resistance to anti-TB drugs, and existence of non-dividing bacilli with little-metabolic rate. Anti-TB drugs which are capable in killing bacilli inside the habitat of granuloma are probably to provide the greatest opportunity to decrease eliminate relapse and length of treatment (Gupta, 2017).

Factors leads to the appearance of TB

The risk factor accountable for evolving disease includes poverty, nutrition, sex, age, immunity, and drug-induced immunosuppression (Tiwari, 2019).

Symptoms and Diagnosis of Tuberculosis

Chest pain, fever, weight loss, cough and blood-stained sputum are some of the remarkable symptoms of TB. Other symptoms may comprise of loss of appetite, tiredness, frequent colds, weakness, and breathlessness. Following symptoms may be due to other reason too. Therefore, sputum inspection is needed for the verification of TB infection.

Diagnosis of TB is mainly grounded on demonstration of acid-fast bacilli, histopathology, and clinical features from the specimens. The diagnosis of TB is primarily based on tuberculin skin tests, chest radiography, and sputum smear microscopy. Numerous quick procedures based on the ribosomal RNA sequencing, analysis of lipid, specific probe, and polymerase chain reaction-restriction fragment length polymorphism have also been employed for the diagnosis purposes (Tiwari, 2019).

Anti TB drugs and their adverse effects

The anti-TB drugs are categorized into five major groups:

First-line drugs- oral drugs (Rifampicin, isoniazid, rifabutin, pyrazinamide, and ethambutol)

Second-line drugs- injectable polypeptide (Viomycin, and capreomycin); Injectable amino-glycosides (Streptomycin, kanamycin, and amikacin);

Injectable and oral fluoroquinolones (Gatifloxacin, ofloxacin, moxifloxacin, levofloxacin, and ciprofloxacin)
Oral drugs (Prothionamide, cycloserine, ethionamide, terizidone, and para-aminosalicylic acid)
Third-line drugs-drugs with undefined role (Nitromidazoles, TMC 207, imipenem plus cilastatin, amoxicillin plus clavulanate, linezolid, and clofazimine).
The utilization of anti-TB drugs is also linked with notable side-effects like dyspepsia, fever, thrombocytopenia, hypersensitivity syndrome, hepatitis, and neuropathy. Such harmful effects are accountable for therapy termination through the intensive phase of treatment, which makes the condition even more typical to be cured. The development of resistant variety of TB provides a forbidding challenge to world TB control attempts. Thus, there is a rapid need of new anti-TB drugs, which are effectual in case of drug-resistant strains and latent TB-infection, safe, and able to shorten the treatment course (Davies, 2003; Torun, 2005; Garner; 2007; Awofeso, 2008; Adhvaryu, 2011; Chhabra, 2012; Goldberg, 2012; Palomino, 2014).

Plants of medicinal value used in Uttarakhand conventional medication for the control of tuberculosis

Uttarakhand engage 17.3% of land area of India, out of which 92.57% is covered under hills and remaining 7.43% is employed under flatland. It is located between 28°53′24′′ to 31°27′50′′N latitude and 77°34′27′′ to 81°02′22′′E longitude. Uttarakhand is a hilly region, sharing boundaries with China and Nepal. On its north-west side situated Himachal Pradesh whereas on the south side is located Uttar Pradesh. It has various type of geographical circumstances and huge diverseness differing from snow covered crest to the sub-tropical Terai region. The vegetation of Garhwal region has been widely investigated by many botanists. Out of 15,000 flowering plant species established in India, around 17% have their therapeutic importance. Many of these species are present in Uttarakhand. Inhabitants of this region are slightly or entirely reliant on forest wealth for fuel, food, and medicine (Singh, 2016). Failure to resolve communicable TB generally arises from an unsuitable on place of inadequate immune reaction. In this concern, the immune structure can be restored by the herbal compounds of the plant sources (Tiwari, 2019). Therefore, current study is focused to document the significance of conventional knowledge utilized for the therapy of tuberculosis in the Uttarakhand, India as manifest in table 1 and figure 1.

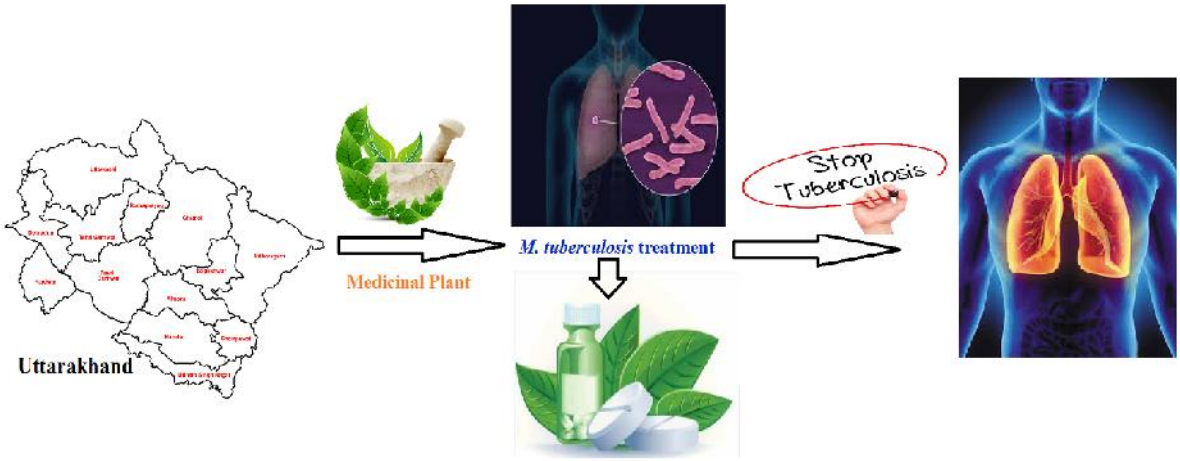

FIGURE 1. Antitubercular properties of medicinal plant in Uttarakhand

DISCUSSION

Therapeutic plants used to cure tuberculosis: After the raise in antibiotic resistance strain cases, there has been hiking of focus in traditional system of medicines. Here, it was reported that there were 55 plants belongs to different families (Rutaceae, Asteraceae, Liliaceae, Aloaceae, Zingiberaceae, Apocynaceae, Amaranthaceae, Acanthaceae, Maratticeae, Moraceae, Oxalidaceae, Fabaceae, Solanaceae, Bombacaceae, Apiaceae, Verbenaceae, Leguminoceae, Cucurbitaceae, Colocasieae, Moraceae, Boroginaceae, Malvaceae, Lamiaceae, Oleaceae, Euphorbiceae, Rubiaceae, Pinaceae, Passifloraceae, Polygonaceae, Selaginellaceae, Araceae, Taxaceae, etc) that displayed the likelihood to be anti-TB. These plants are native to Uttarakhand region and with the help of their local name are effortlessly approachable and their leaves, flower, root, stem or the fruit possessed anti-TB activity. Different techniques that are used for preparing recipes were the infusion of roots and barks, decoction of whole plant, fruit, seeds, and leave in powdered form and extracts of plant.

TABLE 1. Different medicinal plants used in traditional system against *M. tuberculosis*

Scientific name	Family	Local name	Part used: extract/active compound	Activity	Traditional uses in the treatment
Aegle marmelos (L.) Correa	Rutaceae	Bael	90% ethanol leaf extract	The extract was effective in case of H37Rv at the inhibitory concentration of 54.88 µg/ml (Elkington, 2009). Two spoon of leaf powder consume orally for the time period of 2 months (Tawde, 2012)	Intermittent fever, respiratory infection, and cough (Elkington, 2009; Kothari, 2011).
Ageratum conyzoides L.	Asteraceae	Pudina	Methanolic extract of whole plant	Extract displayed restriction of H37Rv at the inhibitory concentration of 1600 µg/ml (Mohamad, 2011).	Fever, pneumonia, and asthma (Okunade, 2002).
Allium odorum L.	Liliaceae	Garlic	80% methanolic extract of leaves	Leaf represented anti-tubercular property counter to H37Rv strain at 1600 µg/ml of minimum inhibitory concentration (Mohamad, 2011).	Cough, and asthma (Borborah, 2014).
Aloe vera L.	Aloaceae	Gwarpatha	80% methanolic extract of leaves	The leaf presented anti-tuberculosis activity in case of H37Rv strain at 1600 µg/ml (Mohamad, 2011).	Bronchitis, and asthma (Sanusi, 2017).
Alpinia purpurata K. Schum.	Zingiberaceae	Kulanjan	methanol extract of leaves/compounds β-sitosteryl-3-O-6′-palmityl-β-D-glucoside, kumatakenin, and β-sitosteryl-β-D-galactoside	The leaf extract indicated 90% restriction counter to H37Rv at the concentration of 100 µg/ml. All isolated compounds represented restriction at MIC > 128 µg/ml (Aguinaldo, 2007).	Cough (Victório, 2011).
Alpinia galanga (L.) Sw.	Zingiberaceae	Lengkuas	Ethanolic and dichloromethane extracts	The extract exhibited dose-dependent inhibitory activity of 18-31% at the concentration of 50µg/ml in case of both strains of H37Rv INH-resistant and sensitive INH strains (Alajmi, 2018)	Asthma, chest pain, bronchitis, and whopping cough
Alpinia zerumbet	Zingiberaceae	Shell Ginger	Methanolic extract of Rhizomes	The rhizome extract indicated 80% of anti-TB activity counter to H37Rvat 100 µg/ml of concentration (Aguinaldo, 2007).	Common cold (Victório, 2011).
Alstonia scholaris (L.) R. Brown	Apocynaceae	Saptaparni	Methanolic extract of leaves/ (+)-manilamine (6), 6,7-seco-angustilobine B (5), 20S-tubotaiwine (4), N_4-methyl angustilobine B (3), a mixture of angustilobine B N_4-oxide (2), 19,20E-vallesamine (1) were isolated from the leaves	Solely 4 showed inhibition activity at 100 µg/ml, while remaining compounds such as 1, 2, 3, 5,6 exhibited activity at >128 µg/ml (Macabeo, 2008).	Fever (Macabeo, 2008)
Amaranthus tricolor L.	Amaranthaceae	Lal Sag	Methanolic extract from the whole plant	Extract exhibited anti-TB activity counter to H37Rv strain at the inhibitory concentration of 1600 µg/ml (Mohamad, 2011).	Cough (Rahmatullah, 2013)
Andrographis paniculata Nees	Acanthaceae	Kalmegh	Aqueous extract of herbs	Aqueous extract exhibited 100% inhibition at 5 mg/ml in case of H37Rv strain and 93.7% inhibition against strain of MDR (Radji, 2015).	Sore throat, and leprosy (Gond, 2014)
Angiopteris evecta (J.R. Forst) Hoffm.	Marattiaceae	Giant fern	80% methanolic extract of leaves	The methanolic extract displayed inhibition activity in case of H37Rv strain at 400 µg/ml (Mohamad, 2011)	Fever, and cough (Puntumchai, 2004)

Artocarpus lakoocha Roxb.	Moraceae	Lakoocha	Lakoochins B (2) and A (1), and dichloromethane from root extract	1 and 2 exhibited anti-TB activity in case of H37Ra strain at 12.5 and 50 µg/ml (Puntumchai, 2004)	Sore throat (Pandey, 2006)
Averrhoa bilimbi L.	Oxalidaceae	Bilimbi	80% methanolic extract of leaves and fruits	The methanol extracts of both represented inhibition of H37Rv at 1600 µg/ml (Mohamad, 2011)	Fever, and whopping cough (Sanusi, 2017)
Abrus precatorius Linn.	Fabaceae	Ratti	Leaf, seed and root decoction	Anti-TB activity (Prakash, 2015)	Chest pain, asthma, fever
Alangium salviifolium (Linn. f) Wang.	Cornaceae	Ankol	Methanolic extract of stem bark	The methanolic extract displayed inhibition activity against MDR and H37Rv strains at varied concentrations (Juyal, 2013; Vijayalakshmi, 2018)	Haemorrhoid, and rheumatism
Barleria lupulina Lindl.	Acanthaceae	Kanta	Aqueous, methanol, chloroform extract of leaves and stem	All extracts of leaves showed inhibition activity against H37Ra strain at 1000 µg/ml Stem chloroform extract showed anti-TB activity at 500 µg/ml in case of H37Ra strain while aqueous and methanol extract presented activities at 1000 µg/ml (Phongpaichit, 2006).	Fever, cough (Moin, 2012).
Blumea balsamifera DC.	Asteraceae	Kukundara	Not stated	The extract exhibited 96.0 and 82.0% restriction counter to MDR and H37Rv at 500 µg/ml, in LRP assay.	Cough (Herowati, 2016)
Capsicum annum	Solanaceae	Shimla Mirch	80% methanolic extract of fruit	The extract showed activity against *Mycobacterium tuberculosis* (da Silva Gebara, 2020)	Sore throat, asthma, anorexia, and cough
Catharanthus roseus	Apocynaceae	Sadabahar	80% methanolic extract of leaves	The extract was inhibitory in case of H37Rv at 1600 µg/ml (Sanusi, 2017)	Fever, and bronchitis
Ceiba pentandra	Bombacaceae	Semal	Methanolic extract of stem-bark	The extract showed anti-TB activity counter to *M. tuberculosis* at 2.5 mg/ml of concentration (Hassan, 2017)	Fever, and bronchitis
Centella asiatica	Apiaceae	Bhrami	Leaf extract	The extract of leaf displayed anti-TB activity against *M. tuberculosis* (Mickymaray, 2010)	Asthma, leprosy, and TB
Chromolaena odorata	Asteraceae	Kalabasa	Flowers: luteolin (4), isosakuranetin (1), acacetin (3), 4′-hydroxy-5,6,7-trimethoxyflavanone (2), all procured from chloroform extract	All compounds displayed activities counter to H37Ra at varied values (µg/ml) 174.8 (1), 606.0 (2), 704.2 (3), 699.3 (4) (Suksamrarn, 2004)	Cough
Citrus aurantiifolia	Rutaceae	Lime	Hexane extract of fruit	The extract presented inhibition activity in case of three mono resistant and one sensitive strains of *M. tuberculosis* H37Rv (Sandoval-Montemayor, 2012)	Asthma, bronchitis, and sore throat
Clerodendrum indicum	Verbenaceae	Hin	80% methanolic extract of flower	The extract expressed anti-TB activity counter to H37Rv strain at 1600 µg/ml (Mukherjee, 2012)	Asthma, and cough
Clitoria ternatea	Leguminosae	Aparajita	80% methanolic extract of whole plant	At 1600 µg/ml, the extract disclosed anti-tubercular activity counter to H37Rv strain (Zingare, 2013)	TB, leprosy, and asthma
Coccinia grandis	Cucurbitaceae	Kundari	Aqueous, chloroform, and methanol extract of leaves	All showed activity in case of H37Ra strain at 1000 µg/ml MIC (Tamilselvan, 2011; Hossain, 2014)	Bronchitis, cough, and asthma
Colocasia esculenta	Colocasieae	Arbi	80% methanolic extract of leaf	The leaf extract presented anti-TB activity in case of H37Rv strain with 1600 µg/ml of MIC (Prajapati,	Coughing with sputum, and asthma

				2011)	
Derris indica L	Leguminosae	Karanj	Flavonoid (1-4) and compounds (5-14) were isolated from the stem and root	All compounds except 2 and 6 displayed anti-TB activity with 6.25 and 200 µg/ml (Koysomboon, 2006)	Whooping cough, and bronchitis
Eclipta prostrata	Asteraceae	Bhringraj	Aqueous, methanol, chloroform extract of whole plant	All extracts showed restriction in MABA counter to H37Ra strain at the varied concentration 62.5, 125, 1000 µg/ml (Sanusi, 2017)	TB, and asthma.
Ficus carica	Moraceae	Anjir	80% methanolic extract of leaves	Methanolic extract showed inhibition activity counter to H37Rv strain at 1600 µg/ml (Mawa, 2013)	Cough, and asthma
Glycosmis pentaphylla	Rutaceae	Ban Nimbu	90% ethanoic extract of flowers and fruits	The extracts of flowers and fruits showed inhibition activities counter to H37Rv strain with the MIC of 93.5 to >100 µg/ml in MABA (Sreejith, 2012)	Cough
Hedychium ellipticum	Zingiberaceae	Kapur Kachri	Rhizomes: dichloromethane and n-hexane/Coronarin E (1) and 16-Hydroxylabda-8(17),11,13-trien-15,16-olide (7) were isolated from the extract	Compounds 1 and 7 showed anti-tubercular activity counter to H37Ra strain at 6.25 and 12.5 µg/ml (Songsri, 2016)	Bronchitis
Heliotropium indicum	Boraginaceae	Hathajori	Aqueous extract of leaves	The crude extract displayed activity in case of H37Ra strain at 20.8 µg/ml MIC (Machan, 2006)	Asthma
Hibiscus rosa-sinensis	Malvaceae	Gudhal	80% methanolic extract of leaves	The extract exhibited activity against H37Rv strain at 1600 µg/ml (Kumar, 2012)	Leprosy, cough
Hyptis suaveolens	Lamiaceae	Vilayti Tulsi	Whole plant: methanol chloroform hexane, /suaveolol (5), suaveolic acid (4), 8α,9α-epoxysuaveolic acid (2)	Compounds 2, 4, 5 presented weak activities in case of H37Ra strain at 100-200 µg/ml (Prawatsri, 2013)	Respiratory tract infections, and fever
Jasminum sambac (L.)	Oleaceae	Chameli	80% methanolic extract of leaves	At MIC = 1600 µg/ml, the crude extract displayed activity counter to H37Rv strain (Mittal, 2012)	Leprosy, and cough
Jatropha curcas	Euphorbiaceae	Arandi	80% methanolic extract of leaves	Methanolic extract exhibited *In vitro* activity in case of H37Rv strain at 1600 µg/ml (Sharma, 2012)	Leprosy
Jatropha integerrima	Euphorbiaceae		Ethanol and dichloromethane /caniojane from the root extract	Caniojane displayed anti-tubercular activity counter to H37Ra strain at 25 µg/ml (Sutthivaiyakit, 2009)	Styptic
Justicia gendarussa	Acanthaceae	Nargandi	80% methanolic extract of leaves	The extract presented inhibition activity in case of H37Rv strain at 1600 µg/ml (Paval, 2009)	Respiratory disorders
Lantana camara	Verbenaceae	Raimuniya	Not stated	In LRP assay, at 500 µg/ml, the extract represented 94.0 and 79.0% anti-TB activity counter to H37Rv and MDR (Kirimuhuzya, 2009)	Asthma, leprosy, and TB
Mimosa rubicaulis Lam.	Fabaceae	Shikanta	Leaf	Paste of Leaf showed anti-TB activity (Dwivedi, 2019)	Skin disease
Momordica charantia	Cucurbitaceae	Karela	Ethanol/2,4-bis (2-phenylpropan-2-y l) phenol (1) from leaves extract	Compound 1 displayed inhibition activity in case of H37Rv strain at 14 µg/ml (Grover, 2004)	Leprosy
Morinda citrifolia	Rubiaceae	Noni	Ethanol and hexane/(E)-phytol (1), cycloartenol (2), stigmasta-	At 100 µg/ml, the crude extract of hexane and ethanol exhibited 89 and 95% of inhibitory activity counter to	Respiratory infection

			4-en-3-one (3), stigmasta-4-22-dien-3-one (4), β-sitosterol (5), stigmasterol (6), campesta-6,22-dien-5α,8α-epidioxy-3β-ol (7) were isolated from the extract of leaves.	H37Rv strain. compounds 3 and 4 in the combination of 2:1 showed activity at 2 µg/ml counter to H37Rv strain followed by 7 and then 1 and 6 . Compound 2 and 5 were less active with 64 and 128 µg/ml MIC, respectively (Saludes, 2002)	
Morus alba	Moraceae	Shahtoot	80% methanolic extract of fruit and leaves	The extract displayed anti-TB activity in case of H37Rv at 1600 µg/ml (Bagachi, 2013)	Cough
Murraya paniculata	Rutaceae	Kamini	Chloroform, methanol, aqueous extract of leaves	Leaf chloroform extract at the 250 µg/ml of MIC exhibited anti-TB activity counter to H37Ra strain whereas both water and methanol extracts displayed inhibition property at 1000 µg/ml (Dosoky, 2016)	Asthma, cough, and expectorant.
Passiflora foetida (Although exotic, still found in 3 districts of Uttarakhand)	Passifloraceae	Jhumka Lata	80% methanolic extract of whole plant	There was restriction counter to H37Rv at MIC = 1600 µg/ml (Sanusi, 2017)	Cough
Pinus roxburghii Sarg.	Pinaceae	Chir	Resin and Pollen dust	Pollen dust and resin with water is useful for tuberculosis (Negi, 2011)	Cancer
Petiveria alliacea	Phytolaccaceae	Guinea Henweed	96% ethanol extract of leaves	Leaf extract displayed anti-TB activity in case of drug resistant and sensitive strains of H37Rv at 1280 µg/ml MIC (Sanusi, 2017))	Antibacterial
Rumex hastatus D. Don	Polygonaceae	Amloraha	Root, Leaf	Leaf juice displayed anti-TB activity (Dwivedi, 2019)	Abdominal colic, and skin disease
Selaginella plana (Desv. Ex. Poir.) Hieron.	Selaginellaceae	Asian spikemoss	80% methanolic extract of whole plant	The extract displayed anti-TB activity counter to H37Rv at 1600 µg/ml MIC *In-vitro* (Sanusi, 2017)	Asthma and coughing
Scindapsus officinalis Roxb.	Araceae	Gajpeepal	Aqueous extract of fruit	Showed anti-TB activity at 62.5 mg/ml of concentration against *Staphylococcus aureus* with inhibition rate of 3.5 mm (Adnan, 2019)	Dysentery, asthma, Bronchitis, asthma, and dysentery
Tabernaemontana coronaria	Apocynaceae	Chandni	n-hexane partition	The n-hexane presented inhibition counter to H37Rv strain at 100-200 µg/ml of concentration (Mohamad, 2018)	TB
Terminalia arjuna (Roxb. Ex DC,)	Combretaceae	Arjun	Bark	Bark possessed anti-TB activity (Dwivedi, 2019)	Fractures, and pneumonia
Taxus baccata Linn.	Taxaceae	Thuner	Stem	Decoction of stem is utilized early morning to treat tuberculosis (Gangwar, 2010).	Cancer
Xanthium strumarium L.	Asteraceae	Gokhra, Chota datura	Leaves (essential oil)	Leaves displayed anti-TB activity counter to *Staphylococcus aureus* at 0.001 mg/ml of concentration with inhibition rate of 42.5 mm (Adnan, 2019) by disc diffusion method.	Rheumatism, and diseased kidney (Moerman, 1998)

Some of these plants were consume directly, while others are being employed in the state of extract, powder or in combination with hair oil, sugar, water, and honey.

In the present survey, water, methanol, ethanol, chloroform, dichloromethane, and n-hexane extracts or the isolated compounds of above-mentioned medicinal plants were evaluated to have anti-tubercular activity against *Staphylococcus aureus* and reference strain *M. tuberculosis* i.e. H37Rv and H37Ra at different minimum inhibitory concentrations.

These strains were primarily reported to be resistant against isoniazid, rifampicin, first-line and second-line of drugs. Hence, further investigations while utilizing the greater number of isolates as well as more fractions of purified extract principles of the above-mentioned plants are required to done to know about the anti-tubercular promises and potential these plants are offering for their use in therapy of drug resistant TB. With these discoveries, we can expect that, this may support the investigators to make up projects that can upgrade the study of natural products which in turn will be helpful in the invention and development of drug.

CONCLUSION

Drug resistant-TB and HIV-TB co-infection are the prominent ultimatum to global well-being. Focusing tubercle bacilli is consistently a question. The present-time anti-TB drugs are not a compelling counter to XDR and MDR strains of TB. So, taking into consideration the harmful situation, the hunt for novel effectual drug is important. The urgent requirement for the invention of novel drugs to decrease the world load of TB has encouraged the analysis of conventional information as the root of effective and novel phyto-therapeutic compounds. Curative plants are the herbal health care to the individual. Local inhabitants of Uttarakhand region majorly utilized these traditionally accessible medicinal plants for their well-being. Uttarakhand has diversity of ethnomedicinal plants that can be used in case of tuberculosis. However, research on mechanism of action, toxicology, and *In-vivo* activity are very restricted. Hence, we highlight on recognizing plant ground on conventional operation and evaluate their constituents against resistant strains (intracellular Mtb/dormant Mtb). There is also a demand to analyze the constituents having new machinery of action in order to conquer the problem of drug resistance.

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Disclosure statement

The authors declare no conflict of interest.

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