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Research Article

Treatment of Tuberculosis using Ethno-medicinal Plants of Amarkantak Region

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Abstract

Background and Objective: Tribals in Amarkantak region of Madhya Pradesh district owing to abject poverty, illiteracy avoid taking modern allopathic treatment for tuberculosis and resort to occult/hokum that aggravates the disease making them potential reservoir of infection. **Materials and Methods:** Present study has employed the novel concept of combining the best of modern TB diagnostics with traditional herbal medicine system for TB treatment. The study has enrolled over hundred cases of uncured TB and also the relapse cases across different age groups, gender and status over the period of 2 years. **Results:** The outcome has validated the efficiency of proposed model of treatment as patients were completely cured of TB without significant relapse cases. Additionally, it has multitude of benefits including economy of cost involved and lack of any potential side effects. Traditional system of medicine has proven itself to be a robust system for TB treatment with multitude of benefits. **Conclusion:** The findings from many more similar studies may pave the way for adopting such model of treatment. This will ease the economic burden on the government exchequer by reducing the cost of the treatment and will increase the cultivation and conservation measures of medicinally important plants.

Key words: Medicinal plants, *Mycobacterium tuberculosis*, tribals, traditional healers, TB diagnostics

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Use of herbs and other plants for the prevention and cure of disease is an ancient practice in India that has more than 5000 years old history^{1,2}. Currently, half of the population relies on these systems for their healthcare needs^{3,4}. Medicinal plants have played an integral part in human life as far as healthcare needs of human and livestock are concerned. India with its varied floral diversity is home to rare herbs and plants having very important medicinal role to play. More than 90% of herbs find its use in the medicines prepared for Ayurveda, Siddha, Unani and Homoeopathy⁵. These plants synthesize chemical compounds having important physiological role to play in human and other animals. Till now 12,000 such compounds have been identified, which is only 10% of the total available compounds though yet to be explored^{5,6}. These chemicals work on the human body in a similar fashion as pharmaceutical drugs with the distinct advantage of no-side-effects^{6,7}.

According to an estimate of World Health Organization (WHO), around 80% of the population of developing or underdeveloped countries relies on traditional medicines based on herbs or plants for their primary healthcare needs^{1,2}. India has rich diversity of plants with perceived use for medicine with more than 3500 species and many more unexplored for the medicinal purposes⁸. Lack of any perceived side effects of these medicines has spiked the demand of medicinal plants throughout the world including European nations^{1,2}.

Tuberculosis has emerged as a major global health issue. According to the estimates of World Health Organization (WHO), around 33% of global population is afflicted with *Mycobacterium tuberculosis* (*M. tuberculosis*) thus making it a most significant burden on human health. Despite being a totally curable disease, tuberculosis is major cause of mortality in human population across different age groups, gender, class and strata^{9,10}. This is further aggravated by the emergence of drug-resistant strains of *M. tuberculosis*, i.e., multidrug-resistance (MDR) forms showing resistant to the two best first-line drugs used to treat tuberculosis, i.e., rifampin (RIF) and isoniazid (INH). Extensively drug-resistant (XDR) tuberculosis shows additional resistance to fluoroquinolones (ciprofloxacin, moxifloxacin, etc.) and an injectable drug (kanamycin, capreomycin or amikacin), the two best classes of second-line drugs¹¹⁻¹³.

The Achanakmar-Amarkantak Biosphere Reserve lies between 21°15'-22°58' North latitude and 81°25'-82°5' longitudes¹⁴. The core region of the biosphere reserve (BR) is situated in Chhattisgarh state whereas the buffer and

transition zones lie partly both in Madhya Pradesh and Chhattisgarh. Residents in BR constitute 48.1% of schedule tribes and 8.46% of schedule caste population. The literacy rate is 26.48%^{14,15-17}.

Madhya Pradesh, being the house to the largest tribal population is particularly vulnerable to the combined threat of TB, MDR/XDR-TB and HIV. Due to its alarming rise, government of Madhya Pradesh has declared it as a notified disease. State has nearly 90,000 patients with addition of 17 MDR-TB cases/month. State has poor show in almost all the reported parameters related to tuberculosis and is much above the national average. For example, 'Saharia' tribe alone in Madhya Pradesh shows a very high prevalence of 1270 reported cases per lakh population against the national average of 216 per lakh. Indore alone has reported 200 MDR cases while the state capital has 37 active cases¹⁸. Tribal's because of lack of awareness, education and socio-economic conditions fall trap to diseases like a tuberculosis, a poor man's disease. At the outset they avoid medical treatment and resort to 'black magic/witchcraft. Even if they take treatments they leave it midway thus acting as reservoir and also developing new resistant strains and infecting others in the process¹⁸.

Current study has employed a novel model system for TB treatment that has incorporated the benefits of modern tuberculosis diagnostics with the traditional herbal medicine for TB treatment. Population sample of over hundred patients showing initial symptoms of tuberculosis, confirmed through modern diagnostic tools. These patients were given concoction of herbal drugs extracted from various parts of the plant.

MATERIALS AND METHODS

Ethno-medicinal plants use by traditional healers of Amarkantak region: The exhaustive list of medicinal plants used by traditional healers is provided in Table 1. The said table provides the complete information of plant regarding taxonomic details, parts utilized for medicinal purposes and the end product (Fig. 1-8).

Preparation of herbal extracts: Bark from the root region was utilized for the preparation of extracts from the plants like Adusa, Arjuna, Koraiya (Kutaj) Ankol and Madar while stem bark was utilized in case of Bhanvarmal, Arjuna, Koraiya (Kutaj) Ankol and Madar. The rhizome of Amahaldi, Kalihaldi, (Shyamahaldi) and Jangali adarak (wild zinger) were utilized in the study. Flower of Adusa (Adhatoda) and the seeds of Datura (Datura metel) were also used for the treatment regimen¹⁹.



Fig. 1: *Adhatoda vasica* Nees showing stem, leaves and flowers



Fig. 2: *Alangium salviifolium* L.f. showing stem, leaves, flowers and fruits



Fig. 3: *Terminalia arjuna* showing bark and leaves

Table 1: List of Medicinal plants traditionally use by tribal for tuberculosis treatment

Name of plants	Scientific name	Family	Availability	Collection area	Useful part	End product
Adua	<i>Adhatoda vasica</i>	Acanthaceae	All India	Amarkantak	Root bark, stem bark, leaves and flower	Bark powder, whole leaf and paste (vr. Kwath) of flower
Ankol	<i>Alangium salviifolium</i>	Alangiaceae	Central India	Amarkantak hills	Stem bark, extract of flower and fruit	Bark power, extract of flower and fruit
Arjuna/Kahua	<i>Terminalia arjuna</i>	Combretaceae	All India	Amarkantak hills	Stem bark and leaves	Kwath/powder of stem and leaves
Ganger	<i>Grewia tenax</i>	Tiliaceae	Indian hills	Amarkantak valley	Mucilage of bark	Mucilage of bark
Amahaldi	<i>Curcuma amada</i>	Zingiberaceae	Indian forest	Amarkantak valley	Rhizome	Powder/kwath
Kali haldi	<i>Curcuma caesia</i>	Zingiberaceae	Throughout India	Amarkantak hills	Rhizome	Powder/Kwath
AK, Madar	<i>Calotropis procera</i>	Asclepiadaceae	Throughout India	Amarkantak valley	Bark of root and stem and flower	Powder/Kwath
Koraiya Kutaj	<i>Holarrhena antidysenterica</i>	Apocynaceae	Central India	Amarkantak	Stem bark and fruit	Powder



Fig. 4: *Grewia tenax* Forsk showing stem, leaves and fruits



Fig. 5: *Curcuma amada* Roxb. showing rhizome, leaves and flower



Fig. 6: *Curcuma caesia* Roxb. showing pieces of rhizomes and leaves



Fig. 7: *Calotropis procera* Ait. showing stem, leaves and flowers



Fig. 8: *Holarrhena antidysenterica* Roxb. Ex-Fleming showing stem, leaves and flowers

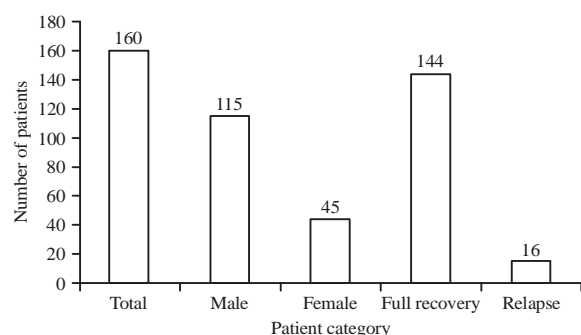


Fig. 9: Analysis of tuberculosis patients in Amarkantak

Following processes were applied for the preparation of herbal extracts/medicines by the tribes/vaidyas for the treatment of tuberculosis:

- The root bark of Adusa, Arjuna, Koraiya, Ankol and Madar were removed by axe or sickle, sheared into small pieces and dried well. The dried root bark lobe was the grinded into fine powder²⁰
- Stem bark of the Adusa, Arjuna, Koraiya, Ankol, Madar and Datura were removed by the sickle or axe followed by cutting into small pieces and sun dried and processed into fine powder. This powder was further mixed with jaggery or honey²⁰
- A kwath prepared by the root bark or stem bark of Arjuna plant is also used with honey for the treatment of the tuberculosis²¹
- Chewing of leaves of Adusa and other plant regularly up to 6 month was recommended as a part of the treatment²¹

Doses: In almost all the cases, the end product, i.e., fine powder was mixed with honey or jaggery to prepare the final

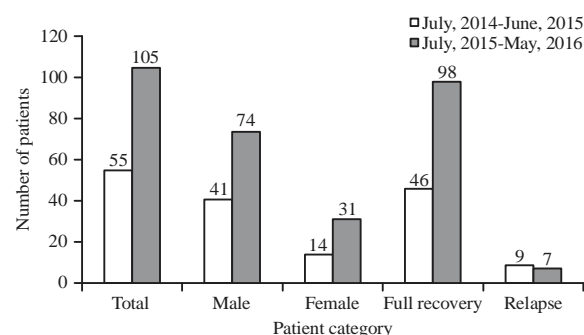


Fig. 10: Graphical analysis of TB cases which occurred during July, 2014-May, 2016 included all 160 patients

dose. For children (<10 years) tablets weighing 1-2 g were given twice a day while for adults (>10 years) tablets weighing 3-5 g were given thrice a day with milk or hot water in both the cases.

Case study: Around 160 patients including 115 male and 45 females were observed from July, 2014-May, 2016 (Fig. 9, Table 2-5) the age of patients ranged from the minimum age of 19 years to the maximum age of 90 years. Out of 160 patients enrolled or under observation, 144 patients recovered completely (Fig. 9-11) within 4-18 months but 16 patients have shown relapse cases (Fig. 9-11). This could be due to improper/irregular taking of medicine and also the internal or external factors or immunity.

Precaution:

- Medicine to be taken properly on regular basis
- Spicy food to be avoided
- Three months followup for checkup

Table 2: Details of patients enrolled from July, 2014-June, 2015 for the treatment via herbal medicine under the supervision of traditional healers

Age of patients	Number of patient		Initial symptoms		Duration	Diagnostics	Mode of treatment
	Male	Female	Male	Female			
19-30	2	-	Cough, chest pain losing weight and respiratory problems		From 1 month	Microscopic analysis of sputum and X-ray	General medicines of allopathy
31-40	6	2	Cough with blood and chest pain		From 2 week	Do	Allopathy
41-50	36	9	Cough with blood, loss of weight due to loss of appetite		From 1 month	Do	Allopathy and homeopathy
51-70	11	3	Cough, chest pain, sputum with blood respiratory problems		From 1 month	Do	Allopathy and herbal

Table 3: Details of patients enrolled from July, 2014-June, 2015 along with pathological and dosage details

Age of patients	Number of patients		Full recovery	Time/duration (months)	Doses/amount	Relapse cases
	Male	Female				
19-30	2	-	2	4-6	TDS*	None
31-40	6	2	3	6-10	TDS	1
41-50	36	9	15	6-10	TDS	6
51-70	11	3	4	6-10	TDS	2

*Thrice in a day

Table 4: Details of patients enrolled from July, 2015-May, 2016 for tuberculosis treatment

Age of patient	Number of patients		Initial symptoms		Duration (weeks)	Diagnostics	Mode of treatment
	Male	Female	Male	Female			
00-20	04	None	Respiratory problems and cough		2	Microscopic analysis of sputum and X-ray	Allopathy medicines
21-40	26	09	Chest pain, cough with blood		2-3	Do	Ayurvedic and allopathy medicine
41-60	42	12	Respiratory problems, cough with sputum		3	Do	Herbal and allopathy
61-90	33	10	Respiratory problems, chest pain and sputum with blood		2-3	Do	Allopathy and herbal medicines

Table 5: Details of patients enrolled from July, 2015-May, 2016 along with pathological and dosage details

Age of patients	Number of patients		Full recovery	Time/duration (months)	Doses/amount	Relapse cases
	Male	Female				
00-20	4	None	4	4-6	TDS*	None
21-40	26	9	15	6-8	TDS	None
41-60	42	12	27	8-9	TDS	5
61-90	33	10	21	8-12	TDS	2

*Thrice in a day

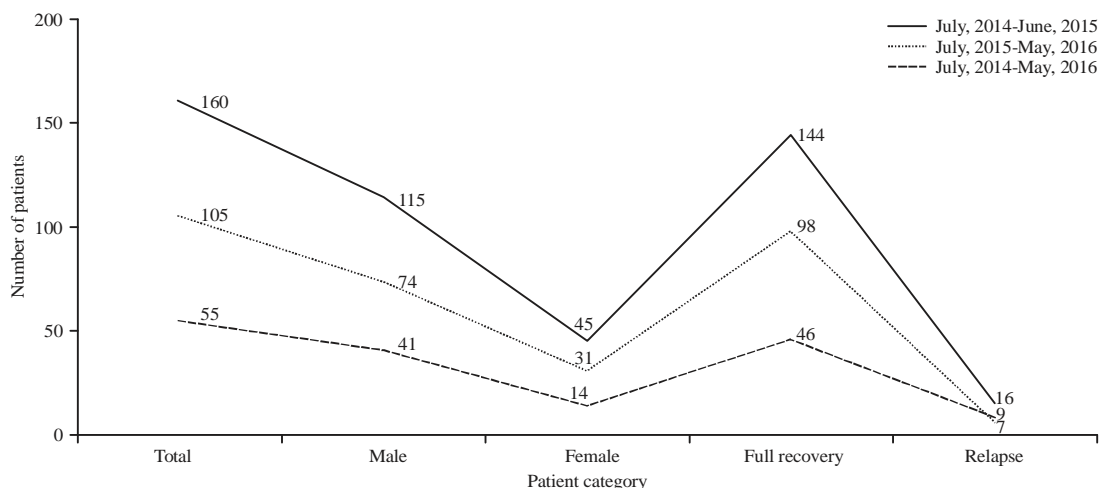


Fig. 11: Genderwise comparative analysis of TB cases

Solid and dotted line shows annual incidences while dashed line shows overall cases during the study period

- Heightened sense of inferiority due to illiteracy, poverty and lack of awareness, most of the time tribals refuse to acknowledge that they are suffering from some serious ailment. This prevents them from taking treatment thus not only aggravating the disease but also acting as a potential reservoir of infection

RESULTS

The novel strategy of combining modern TB diagnostics with herbal medicine based treatment has yielded good results with only 10% of relapse cases. These relapse cases were largely due to other factors than the treatment itself (Table 3, 5). The number and history of patients like initial symptoms and their persistence, mode of diagnosis and treatment are given in the Table 2 and 4. As evident from the tables, in all the cases patients have initially gone for the allopathic treatment or allopathic treatment along with herbal medicines in few cases. However, not getting sufficient relief after continued treatment they opted for the treatment offered by traditional healers based on herbal medicines. Surprisingly, maximum frequency of TB can be seen in the middle age group (41-50 years), while minimum in the case of adolescents to youth (19-30 years). This could be attributed to the efficiency of immune system that weakens as the age advances.

Details of treatment in terms of dosage, duration of treatment and relapse cases if any is given in the Table 3 and 5. As mentioned above, maximum observed cases of relapse are in the middle age group (41-50 years) and minimum in case of adolescents to youth (19-30 years), which

is again due to the efficacy of immune system. A strong immune system follows the treatment regimen more effectively and without any side effects as compared to a weak immune system. Duration of treatment further attests to that, as for the youth a treatment duration of 4-6 months were sufficient to get them rid of disease without a single case of relapse which is maximum in case of middle age group patients. Old age patients have shown better results in terms of efficacy of treatment as well as relapse cases. Although, immune system is highly compromised in the old ages but the results observed here might be due to decrease in the physical activity.

DISCUSSION

Amarkantak is presumed to be the home of treasure trove of herbs of medicinally important plants endemic to the region^{5,14}. This region is predominantly a tribal region occupied by one amongst the most primitive tribes. The tribes due to their ignorance, beliefs and abject poverty refuse to follow modern treatment regimen and hence resort to hokum/occult practices and sometimes go for traditional healers who largely use herbal preparations for the treatment^{22,23}. These traditional healers inherit the system of treatment protocol from their forefathers and keep on transmitting to the next generation as heir-loom. This system of treatment is mostly based on experience and beliefs rather than on the foundation of pure scientific logic^{5,22,23}.

The submitted case study has nevertheless tried to combine the best of traditional and modern medicine system as the traditional system have no means of accurate diagnosis.

The diagnosis in such a system is based on few observable symptoms that may lead to false positive or false negative results leading to wrong treatment. Therefore, authors tried to depend on modern diagnostic tools like 'microscopic analysis of sputum' and chest X-ray to doubly confirm the suspected cases of tuberculosis primarily based on initial symptoms. Once the diagnosis confirmed the TB, patient was taken under the 'traditional treatment regimen' conducted by traditional healers. The treatment protocol follows age dependent dosage^{24,25}.

A study by Negina *et al.*²⁶ has validated that TB related deaths are more common in people over the age of 50 years. Elder people are more prone to develop extra-pulmonary and atypical TB, which is difficult to diagnose. This is further complicated by side effects of the allopathic drug prescribed as immunity and strength of body gets weakened with advancing age. Older people also develop complications due to the presence of drug resistant strains. Estimates from global burden of disease have clearly shown that more than 57% of deaths occurred among the older people. For example, in Australasia this estimate is 92%, in Western Europe (93%) while lesser developed economies like East Asia (79%) and tropical Latin America (65%)²⁶. A number of factors work together to inflate the TB estimates among older people, diagnosis is one such factor. A meta-analysis by several studies has enlisted the difficulties in TB diagnostics^{27,28}. This is because prominent symptoms like haemoptysis, dyspnoea and fever are less observable in advanced age. Further, tendency to cough out high quality sputum is also reduced in older people. Mantoux skin test gives false negative results^{29,30}. Older people have compromised immune system owing to associated chronic co-morbidities like diabetes, organ transplant, cancer, immune senescence combined with dementia. People co-infected with tuberculosis and diabetes are several folds more likely to fail treatment due to disturbed glycaemic control^{31,32}. This is further aggravated by social marginalization, reduced mobility and financial dependency demotivates them to seek curative treatment. Overall, tuberculosis treatment in older people often gets failed or yield poor results due to delayed diagnosis, drug related complications owing to associated co-morbidities and financial dependency.

CONCLUSION

- The submitted study validates the efficacy of combination of modern diagnostics with the traditional herbal medicine system for TB treatment
- This novel system has achieved the cure rate of around 90%

- Minimum number of relapse cases further establishes the usefulness of the treatment
- Economy of cost involved and lack of any potential side effects are the added advantage of this treatment regimen
- There is an urgent need for escalation of such studies showing and validating the efficacy of herbal medicine
- Advanced research and state of art molecular techniques need to focus on finding ways to empirically validate the protocols of such treatment

SIGNIFICANCE STATEMENTS

This study discovers the novel system of treatment combining modern diagnostics with traditional herb based treatment. This study will provide a platform and help researchers to undertake many similar studies that will elucidate the underlying mechanism of active principle involved in the cure.

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REFERENCES

1. Petrovska, B.B., 2012. Historical review of medicinal plants' usage. *Pharmacogn. Rev.*, 6: 1-5.
2. Pan, S.Y., G. Litscher, S.H. Gao, S.F. Zhou and Z.L. Yu *et al.*, 2014. Historical perspective of traditional indigenous medical practices: The current renaissance and conservation of herbal resources. *Evidence-Based Complement. Altern. Med.* 10.1155/2014/525340.
3. Mukhopadhyay, B., A. Chakrabarty, S. Ghosal and S.K. Bhattacharya, 2001. Immunomodulatory Properties of Some Indian Medicinal Plants: Emerging Drugs. In: *Molecular Aspects of Asian Medicine*, Mori, A. and T. Sato (Eds.). PJD Publications, Westbury, USA., pp: 445-460.
4. Bharti, S., V.D. Wahane and V.L. Kumar, 2010. Protective effect of *Calotropis procera* latex extracts on experimentally induced gastric ulcers in rat. *J. Ethnopharmacol.*, 127: 440-444.
5. Prana, I.C., R.K. Ahirwar and G.K. Singh, 2014. Traditional medicinal knowledge about some herbaceous plants used by Baiga tribes of Bajag Forest district Dindori Madhya Pradesh India. *Indian J. Sci. Res.*, 3: 2232-2236.

6. Lai, P.K. and J. Roy, 2004. Antimicrobial and chemopreventive properties of herbs and spices. *Curr. Med. Chem.*, 11: 1451-1460.
7. Tapsell, L.C., I. Hemphill, L. Cobiac, C.S. Patch and D.R. Sullivan *et al.*, 2006. Health benefits of herbs and spices: The past, the present, the future. *Med. J. Aust.*, 185: S4-S24.
8. Singh, P. and S.S. Dash, 2014. Plant Discoveries 2013-New Genera, Species and New Records. Botanical Survey of India, Kolkata, India.
9. Sandhu, G.K., 2011. Tuberculosis: Current situation, challenges and overview of its control programs in India. *J. Global. Infect. Dis.*, 3: 143-150.
10. Sulis, G., A. Roggi, A. Matteelli and M.C. Raviglione, 2014. Tuberculosis: Epidemiology and control. *Mediterr. J. Hematol. Infect. Dis.*, Vol. 6, No. 1. 10.4084/mjihid.2014.070.
11. Sachdeva, K.S., A. Kumar, P. Dewan, A. Kumar and S. Satyanarayana, 2012. New vision for Revised National Tuberculosis Control Programme (RNTCP): Universal access-“reaching the un-reached”. *Indian J. Med. Res.*, 135: 690-694.
12. WHO., 2011. WHO warns against the use of inaccurate blood tests for active tuberculosis (TB). World Health Organization, Geneva, Switzerland. http://www.who.int/tb/features_archive/20july11_end_to_inaccurate_tb_blood_tests/en/
13. Central TB Division, 2008. RNTCP annual status report 2008. Directorate General of Health Services, Ministry of Health and Family Welfare, Government of India, New Delhi.
14. Joshi, K.C., M.S. Negi and A.D. Tiple, 2010. Achanakmar-Amarkantak biosphere reserve. Biosphere Reserves Information Series (BRIS), Tropical Forest Research Institute, Indian Council of Forestry Research and Education, Jabalpur, India.
15. Roychoudhury, N., R. Sharma and D.K. Gupta, 2016. Achanakmar-Amarkantak biosphere reserve, India: A diverse tropical forest ecosystem. *Van Sangyan*, 3: 1-10.
16. Shukla, A.N. and K.P. Singh, 2012. Glimpses of the lichen flora of Achanakmar-Amarkantak biosphere reserve in Central India. *Am. J. Plant Sci.*, 3: 697-708.
17. Tiwari, A.P., B. Joshi and A.A. Ansari, 2012. Less known ethnomedicinal uses of some orchids by the tribal inhabitants of Amarkantak Plateau, Madhya Pradesh, India. *Nat. Sci.*, 10: 33-37.
18. Keshavjee, S. and P.E. Farmer, 2013. History of tuberculosis and drug resistance. *N. Engl. J. Med.*, 368: 89-90.
19. Dubey, N.K., R. Kumar and P. Tripathi, 2004. Global promotion of herbal medicine: India's opportunity. *Curr. Sci.*, 86: 37-41.
20. Aggarwal, B.B., S. Prasad, S. Reuter, R. Kannappan and V.R. Yadav *et al.*, 2011. Identification of novel anti-inflammatory agents from Ayurvedic medicine for prevention of chronic diseases: "Reverse pharmacology" and "bedside to bench" approach. *Curr. Drug Targets*, 12: 1595-1653.
21. Pandey, A. and S. Tripathi, 2014. Concept of standardization, extraction and pre phytochemical screening strategies for herbal drug. *J. Pharmacogn. Phytochem.*, 2: 115-119.
22. Semanya, S.S. and A. Maroyi, 2013. Medicinal plants used for the treatment of tuberculosis by bapedi Traditional healers in three districts of the Limpopo Province, South Africa. *Afr. J. Tradit. Complement. Altern. Med.*, 10: 316-323.
23. Amoah, S.K., L.P. Sandjo, M.L. Bazzo, S.N. Leite and M.W. Biavatti, 2014. Herbalists, traditional healers and pharmacists: A view of the tuberculosis in Ghana. *Rev. Bras. Farmacogn.*, 24: 89-95.
24. Rai, R. and R. Nath, 2005. Use of medicinal plants by traditional herbal healers in Central India. *Indian For.*, 131: 463-468.
25. Shafiq, M., R.A. Begum and R. Sridhar, 2006. Drug resistance profile among post-Cat II sputum positive patients-critical analysis. Proceedings of the 60th National Conference on Tuberculosis and Chest Diseases, February 23-26, 2006, Lucknow, India, pp: 163-174.
26. Negin, J., S. Abimbola and B.J. Marais, 2015. Tuberculosis among older adults-time to take notice. *Int. J. Infect. Dis.*, 32: 135-137.
27. Tsara, V., E. Serasli and P. Christaki, 2009. Problems in diagnosis and treatment of tuberculosis infection. *Hippokratia*, 13: 20-22.
28. Nema, V., 2012. Tuberculosis diagnostics: Challenges and opportunities. *Lung India*, 29: 259-266.
29. Rajgopalan, S., 2001. Tuberculosis and aging: A global health problem. *Clin. Infect. Dis.*, 33: 1034-1039.
30. Kobashi, Y., K. Mouri, S. Yagi, Y. Obase and N. Miyashita *et al.*, 2008. Clinical utility of the QuantiFERON TB-2G test for elderly patients with active tuberculosis. *Chest*, 133: 1196-1202.
31. Mi, F., S. Tan, L. Liang, A.D. Harries and S.G. Hinderaker *et al.*, 2013. Diabetes mellitus and tuberculosis: Pattern of tuberculosis, two-month smear conversion and treatment outcomes in Guangzhou, China. *Trop. Med. Int. Health*, 18: 1379-1385.
32. Riza, A.L., F. Pearson, C. Ugarte-Gil, B. Alisjahbana and S. van de Vijver *et al.*, 2014. Clinical management of concurrent diabetes and tuberculosis and the implications for patient services. *Lancet Diabetes Endocrinol.*, 2: 740-753.