Journal of Ethnopharmacology 151 (2014) 999–1004

Contents lists available at ScienceDirect

Journal of Ethnopharmacology

journal homepage: www.elsevier.com/locate/jep

Research Paper

Knowledge on plants used traditionally in the treatment of tuberculosis in Uganda

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ARTICLE INFO

Article history:
Received 19 October 2013
Received in revised form
10 December 2013
Accepted 11 December 2013
Available online 21 December 2013

Keywords:
Traditional knowledge
Ethnobotany
Herbal medicine
Tuberculosis

ABSTRACT

Ethnopharmacological relevance: Tuberculosis (TB) is one of the leading causes of morbidity and mortality globally. The disease is especially important because of increasing drug resistant strains and co infection with human immune virus (HIV) and acquired immune disease syndrome (AIDS). Because of this there is need to identify new leads that can be developed into new drugs. The objectives of this study were to (1) document plant species commonly used by traditional medicine practitioners (TMPs) to treat TB, methods of preparation and administration of drugs (2) document disease recognition by TMPs and (3) document medicine preservation and packaging practices by TMPs.
Materials and methods: We interviewed 40 TMPs from Mpigi and Butambala districts using a guided questionnaire.
Results: A total of 90 plant species, distributed within 44 families were documented. Priority plants identified include *Zanthoxylum leprieurii, Piptadeniastrum africanum, Albizia coriaria* and *Rubia cordifolia* which were most mentioned by TMPs. TMPs had knowledge of how TB is transmitted and they admitted that it is closely associated with HIV. Decoctions of multiple plant species were commonly used. Plant parts frequently used were leaves followed by the stem bark and root bark. The TMPs had insufficient knowledge about packaging and preservation techniques.
Conclusion: Plant based therapies for treating TB have been identified in this study and further investigation of these plants is appropriate as these, may be developed into new drugs to curb the resistant strains of TB.

1. Introduction

Tuberculosis (TB) is a major public health problem in the world that claims up to 2 million lives annually (WHO, 2012). Its reservoir has been estimated at 8.7 billion people. A key challenge of TB control in the last decade has been the upsurge in drug resistant strains. Multi drug resistant tuberculosis (MDR TB) and, Extensively drug resistant tuberculosis (XDR TB) are resistant to the most affordable, efficacious and readily available TB drugs (Centre for Disease Control, 2005). Additionally treatment of TB and HIV AIDS is difficult due to the adverse drug interactions involved (Chan and Iseman, 2002). There is therefore an imperative need to develop a new battery of drugs to curb the resistant TB strains.

Natural products especially plants continue to provide new and important leads in the drug discovery process (Balunas and Kinghorn, 2005). The first step in drug discovery is to document material traditionally used to treat an ailment. Uganda is endowed with a rich diversity of medicinal plants as compared to other parts of Africa (Eilu and Winterbottom, 2006). There is however fear that indigenous knowledge about traditional medicine is slowly being lost (Ssegawa and Kasenene, 2007). Documentation of such knowledge will lead to its conservation as well as facilitate future research on medicinal plant safety and efficacy to validate traditional use.

This study documents medicinal plants used by healers in the districts of Mpigi and Butambala, in central Uganda. Specifically, we documented plant species commonly used by traditional medicine practitioners to treat TB, methods of preparation and administration. We also documented disease recognition by TMPs, and lastly documented medicine preservation and packaging practices by TMPs.

2. Study area/population

The study was carried out from Mpigi (0°13′ N 32°19′ E) and Butambala (0°10′ N 32°19′ E) districts which are located in central Uganda 40 km and 82 km from Kampala city centre, respectively. Butambala was formerly a county under Mpigi district but was

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http://dx.doi.org/10.1016/j.jep.2013.12.020

Table 1
Plant species reported by TMPs ($n=40$) for the treatment of TB, parts used, Local names and frequency of mention. (L—Leaves, SB—stem bark, F—fruit, RT—root bark, WP—whole plant, S—seeds, H—husks, B—bulb, BL—Bunalema Lydia).

Plant name	Family	Local name (Luganda)	Voucher no.	Part used	Frequency of mention
Zanthoxylum leprieurii Guill. & Perr.	*Rutaceae*	Munyenye	BL030	SB	24
Piptadeniastrum africanum (Hook. f.) Brenan	*Fabaceae*	Mpewere	BL040	SB	16
Albizia coriaria Welw.ex Oliv.	*Fabaceae*	Mugavu	BL070	SB	15
Rubia cordifolia L.	*Rubiaceae*	Kasalabakesi	BL010	L/WP	15
Dracaena steudneri Engl.	*Asparagaceae*	Kajjolyenjovu	BL072	SB	14
Canarium schweinfurthii Engl.	*Burseraceae*	Muwafu	BL035	SB, S	13
Callistemon citrinus (Curtis) Skeels	*Myrtaceae*	Mwambala butonya	BL014	L/SB	13
Combretum molle R.Br. ex. G. Don.	*Combretaceae*	Ndagi	BL014	SB	12
Erythrina abyssinica Lam.	*Fabaceae*	Eggirikiti	BL007	SB	11
Phaseolus vulgaris L.	*Fabaceae*	Bijanjaro	BL044	H	11
Hibiscus fuscus Garcke	*Malvaceae*	Lusaala	BL036	L	10
Garcinia buchananii Baker	*Clusiaceae*	Musaali	BL039	SB	9
Blighia unijugata Baker	*Sapindaceae*	Enkuza nyana	BL031	SB	8
Mangifera indica L.	*Anacardiaceae*	Muyembe	BL052	SB	8
Toddalia asiatica (L.) Lam.	*Rutaceae*	Kawule	BL060	L	8
Prunus africana (Hook.f.) Kalkman	*Rosaceae*	Ntaseesa	BL 076	SB	8
Entada abyssinica Steud. ex A. Rich.	*Fabaceae*	Mwolola	BL054	SB	6
Ribes uva-crispa L.	*Grossulariaceae*	Entuntunu	BL034	L	6
Myrica kandtiana Engl.	*Myricaceae*	Enkikimbo	BL045	F/L/SB/RB	5
Spathodea campanulata P. Beauv.	*Bignoniaceae*	Kifabakazi	BL009	SB	4
Ficus glumosa Delile	*Moraceae*	Muwo	BL087	SB	4
Celosia trigyna L.	*Amaranthaceae*	Kakubaggiri	BL015	L	4
Eucalyptus spp.	*Myrtaceae*	Kalitunsi	BL038	L	4
Vernonia amygdalina Delile	*Asteraceae*	Mululuza	BL016	L	3
Lantana camara L.	*Verbenaceae*	Kayukiyuki	BL064	L/WP	3
Aspilia africana (Pers.) C.D. Adams	*Asteraceae*	Makaayi	BL066	RB/L	3
Carica papaya L.	*Caricaceae*	Papaali	BL063	L	3
Triumfetta flavescens Hochst. ex A. Rich.	*Malvaceae*	Luwugula	BL053	S	3
Momordica foetida Schumach.	*Cucurbitaceae*	Bombo	BL008	L	3
Gnaphalium purpureum L.	*Asteraceae*	Omuya		L	3
Zingiber officinale Roscoe	*Zingiberaceae*	Ntangawuzi	BL029	L	2
Milicia excelsa (Welw.) C.C. Berg	*Moraceae*	Muvule	BL024	L	2
Rhus vulgaris Meikle	*Anacardiaceae*	Kakwanskwanso	BL057	SB/L	2
Albizia spp.	*Fabaceae*	Ennongo	BL056	SB	2
Bidens pilosa L.	*Asteraceae*	Sere	BL046	L	2
Warburgia ugandensis Sprague	*Canellaceae*	Abaki	BL100	SB	2
Acacia spectabilis A. Cunn. ex Benth.	*Fabaceae*	Gasiya	BL055	L	2
Allium sativum L.	*Amaryllidaceae*	Katungulu chumu	BL074	F	2
Trichilia dregeana Sond.	*Meliaceae*	Sekoba	BL032	SB	2
Plectranthus barbatus Andrews	*Lamiaceae*	Ekibankulata	BL019	L	2
Tithonia diversifolia (Hemsl.) A. Gray	*Asteraceae*	Ekimyula	BL073	SB	2
Indigofera emarginella Steud. ex A. Rich.	*Fabaceae*	Olutunga nsonzi	BL079	l/F	2
Cinnamomum zeylanicum Blume	*Lauraceae*	Mudalasini	BL077	SB	1
Azadirachta indica A. Juss.	*Meliaceae*	Neem tree	BL078	L	1
Maytenus senegalensis (Lam.) Excell	*Celastraceae*	Naligwalimu	BL082	L and F	1
Zanthoxylum chalybeum Engl.	*Rutaceae*	Ntale ya ddungu	BL090	SB	1
Syzygium cumini (L.) Skeels	*Myrtaceae*	Jambula	BL017	SB	1
Ficus natalensis Hochst.	*Moraceae*	Omutuba	BL062	SB	1
Aloe vera (L.) Burm. f.	*Xanthorrhoeaceae*	Kigaji	BL026	L	1
Pseudospondia microcarpa (A. Rich.) Engl.	*Anacardiaceae*	Muziru	BL033	SB	1
Lippia grandifolia Hochst. ex A. Rich	*Verbenaceae*	Olugumaguma	BL091	L	1
Sapium ellipticum (Hochst.) Pax	*Euphorbiaceae*	Omusasa	BL067	SB	1
Coffea canephora Pierre ex A. Froehner	*Rubiaceae*	Emwanyi	BL065	S/SB	1
Chaetacme aristata Planch.	*Ulmaceae*	Embutami		L	1
Persea americana Mill.	*Lauraceae*	Ovacado	BL068	SB	1
Desmodium salicifolium (Poir.) D.C.	*Fabaceae*	Enkolimbo	BL012	L	1
Fleurya aestuans (L.) Gaudich. ex Miq.	*Urticaceae*	Munyango	BL013	L	1
Solanum incanum L.	*Solanaceae*	Entengo ennene	BL004	L	1
Kalanchoe glaucescens Planch. ex benth	*Crassulaceae*	Ekiyondo ekyeru	BL059	L	1
Bridelia micrantha (Hochst.) Baill.	*Euphorbiaceae*	Katazamitti	BL047	SB	1
Phyllanthus reticulatus Poir.	Phyllanthaceae	Mutulika	BL048	L	1
Tetradenia riparia (Hochst.) Codd	*Lamiaceae*	Ekyewamala	BL021	L	1
Antiaris toxicaria Lesch.	*Moraceae*	Kirundu	BL061	SB	1
Moringa oleifera Lam.	*Moraceae*	Moringa	BL037	f	1
Acacia hockii De Wild.	*Fabaceae*	Kasana	BL041	L	1
Solanum spp.	*Solanaceae*	Katunkuma	BL022	L/F	1
Cymbopogon citratus D.C. ex Stapf	*Poaceae*	Kisubi	BL011	L	1
Phaseolus lunatus L.	*Fabaceae*	Kayindiyindi	BL023	L	1
Plumbago zeylanica L.	*Plumbaginaceae*	Musajja abanda	BL092	L	1
Ageratum conyzoides L.	*Asteraceae*	Namirembe	BL049	WP	1
Morinda lucida Benth.	*Rubiaceae*	Kabaja nsayi	BL093	SB	1
Podocarpus usambarensis Pilg.	*Podocarpaceae*	Kamusenene	BL003	L	1
Vernonia cinerea (L.) Less.	*Asteraceae*	Kayayana	BL006	L	1
Alangium chinense (Lour.) Harms	*Cornaceae*	Omusiisa	BL027	SB	1

Table 1 (*continued*)

Plant name	Family	Local name (Luganda)	Voucher no.	Part used	Frequency of mention
Steganotaenia araliacea Hochst.	*Apiaceae*	Omuwanula	BL086	SB	1
Kigelia africana (Lam.) Benth.	*Bignoniaceae*	Omusa	BL005	L	1
Alchornea cordifolia (Schumach. & Thonn.) Müll. Arg.	*Euphorbiaceae*	Luzibaziba	BL101	L	1
Cassia didymobotrya Frensen.	*Fabaceae*	Omucuula	BL018	L	1
Crotalaria agatiflora Scheinf.	*Fabaceae*	Kasamba ndege	BL054	L	1
Centella asiatica (L.) Urb.	*Apiaceae*	Kabbo kabakyala	BL042	L	1
Citropsis articulata (Willd. ex Spreng.) Swingle & M. Kellerm.	*Rutaceae*	Akatimbolo	BL089	F	1
Argemone mexicana L.	*Papaveraceae*	Akatovu akeeru	BL050	F/WP	1
Phyllanthus amarus Schumach. & Thonn.	*Phyllanthaceae*	Kabalila mugongo	BL043	L	1
Hyptis suaveolens (L.) Poit.	*Lamiaceae*	Kawetale	BL085	L	1
Catharanthus roseus (L.) G. Don	*Apocynaceae*	Sekajja	BL075	L	1
Lippia javanica (Burm f.) Spreng.	*Verbenaceae*	Kisumuluzo	BL083	L	1
Pycnanthus angolensis (Welw.) Warb.	*Myristicaceae*	Olunaaba	BL069	SB	1
Parkia filicoidea Welw. ex Oliv.	*Fabaceae*	Jjoge	BL098	SB	1
Trimeria grandifolia (Hochst.) Warb.	*Salicaceae*	Nabumba	BL099	SB	1
Aristolochia elegans Mast.	*Aristolochiaceae*	Nabuseero	BL080	WP	1

recently elevated to district status. The districts are at an altitudinal range of 1182–1341 m, have an average rainfall of approximately 1320 mm per annum and temperatures ranging between 20 °C and 30 °C. The land cover is a combination of tropical forests, woodlands, grassland, wetland and arable land. The population of Mpigi district is estimated at 454,000 while that of Butambala is 98,200 people. Both Mpigi and Butambala are largely rural districts with only 8.4% of the population living in urban areas. The main economic activities in the districts include semi-intensive agriculture, fishing, trade and tourism (STRIDES for Family Health, 2009). Of these, agriculture remains the mainstay and is practiced by the majority of the rural population. The districts are dominated by the Ganda tribe and Luganda is the local language spoken.

The healers in this study belonged to a Non-Government Organization (NGO) known as Promotion Des Medecines Traditionnelles_Uganda chapter (PROMETRA-Uganda). PROMETRA-Uganda is an affiliate of PROMETRA international and in Uganda; it mobilizes, organizes, sensitizes and trains TMPs on proper use of medicinal plants. It has a total membership of 811 TMPs and 40% of which are herbalists.

3. Methods

Data for this survey were gathered using an ethno botanical approach. The inclusion criterion for TMPs was based on their reputation to treat TB in the community and willingness to participate in the research. We interviewed 40 TMPs who were identified with the help of PROMETRA. Information on plant species used, preparation, preservation, packaging methods and dosages was collected through an in-depth interview using a guided questionnaire. The interviews were conducted in Luganda the local language. Voucher specimen (indexed as BL) of all mentioned species were collected and identified by staff of Makerere University Herbarium (MHU). Species are named according to the Flora of Tropical East Africa (FTEA). Flora of Tropical East Africa is a volume of close to 200 individual books and each family has its own individual volume and author.

Data were entered in Microsoft Excel® program and summarized into frequencies. Pearson's correlation was used to establish the relationship between knowledge and age of participants. It was calculated using STATA 11 Software. The Informant consensus factor (F_{ic}) was also calculated. This factor estimates the relationship between the "number of use-reports (n_{ur}) minus the number of taxa used (n_t)" and the "number of use-reports in each category minus 1" (Trotter and Logan (1986)). F_{ic} was thus calculated using the following formula

$$F_{ic} = \frac{n_{ur} - n_t}{n_{ur} - 1} \quad (1)$$

Ethical approval for this study was granted by the Uganda National Council of Science and Technology (UNCST) (HS 1288) and Makerere University Institutional Review Board. Before interviewing any TMP, the objectives of the study, method and planned use of the information were explained to them and permission to conduct the interview was sought. Written consent was obtained in all cases before the interview was carried out.

4. Results

4.1. Demographics

Among the 40 TMPs interviewed, 22% of them were female. Thirteen of them were from Butambala district and 27 were from Mpigi district. The average age of the respondents was 47 years (range is 25–68years). Most (93%) TMPs had attained primary and secondary education. Farming and animal keeping were their primary sources of income while traditional healing was practiced secondarily. On average, TMPs receive 2 TB patients annually.

4.2. Plants knowledge

A total of 90 plant species, distributed within 44 families were mentioned by TMPs for the treatment of TB (Table 1). The families with the largest number of species were *Fabaceae* 14.7%, *Asteraceae* 7.9%, *Moraceae* 5.7% and *Rutaceae* 4.5%.

The Informant Consesus factor in this study was 0.72 and the plants that were mentioned by more than ten TMPs included *Piptadeniastrum africanum*, *Zanthoxylum leprieurii*, *Dracaena steudneri*, *Callistemon citrinus*, *Albizia coriaria, Combretum molle*, *Canarium schweinfurthi* and *Erythrina abyssinica*.

The plant parts most used in treatment of TB were the stem bark and leaves (Fig. 1). Healing knowledge was assessed based on the number of efficacious plant species mentioned by each respondent. The most knowledgeable TMP mentioned five plant species whose efficacy has been evaluated. Pearson's correlation test between age and knowledge was calculated and it was; $r = 0.09$.

4.3. Medicine preparation and administration

The principal methods of remedy preparation were decoctions, followed by burning plants to ash and infusions. Some plant species

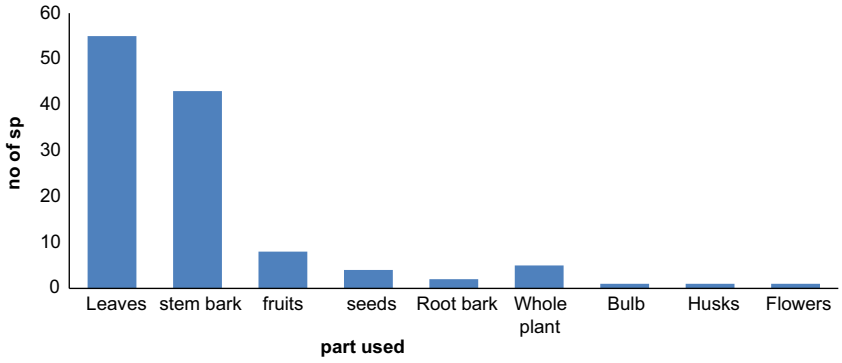

Fig. 1. Plant parts used as medicines, showing the respective number of medicinal plants for which that plant part is used.

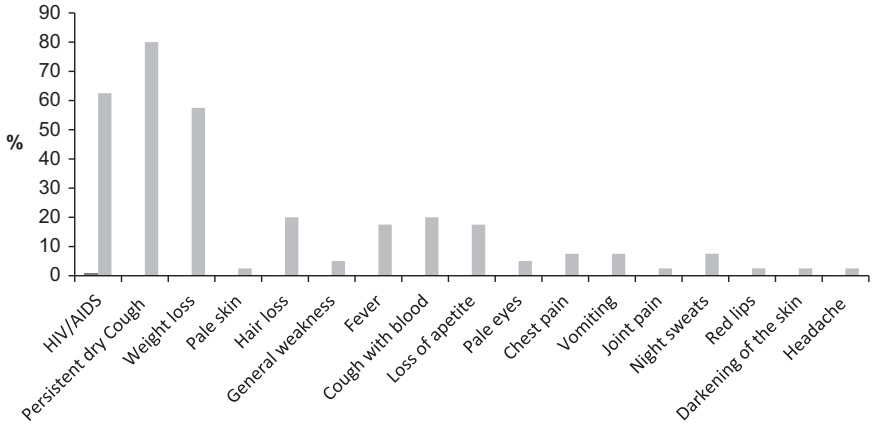

Fig. 2. shows symptoms of TB mentioned by TMPs and number of mention in percentages.

do not require any form of preparation for example *Zingiber officinale* whose leaves are crushed and chewed. It was reported that preparation of decoctions could take up to eight hours of boiling depending on the species and part used. Root barks and stem barks are boiled longer than the leaves. The boiling temperatures are also varied from high to low during the boiling process. Taste and color change of the concoction are used to indicate that the boiling process is complete.

The routes of administration that were used included the oral route and the inhalation route. The doses used in the treatment varied amongst different TMPs depending on the method of preparation and plant species used. The doses ranged from 1/2 tablespoon to 1/2 cup three times a day until the patient was relieved of all symptoms. Patient self-reports and disappearance of symptoms was used to measure treatment outcomes. If the patient showed no improvement, they were referred to either a superior TMP (47%) or to the hospitals (53%).

4.4. Preservation and packaging practices

Traditional medicines are preserved through use of plants, rock salt, alcohol, honey and sodium benzoate. Plants used as preservatives include *Eucalyptus* species and *Bidens pilosa*. The leaves of these species are dried, powdered and boiled together with the decoction. Some medicines are prepared when required and do not need preservation. Packaging of the concoctions was done in used plastic mineral water bottles and plastic bags though glass bottles and old newspapers were also mentioned. The storage period before the medicines lose their effectiveness was between one month to a year depending on whether it is stored as a concoction or powder.

4.5. Knowledge about TB

TMPs admitted that TB is difficult to treat and that it takes a long time to cure. They knew that it is a contagious airborne disease that is caused by a bacterium though they also mentioned that it is genetic and can be congenital. The predisposing factors for infection that were mentioned included sharing of utensils with TB patients, poorly aerated environments and kissing among others. They also noted that most TB patients that they receive are co-infected with HIV/AIDS. HIV/AIDS and prolonged dry cough are the major symptoms from which they tell that one has TB (Fig. 2). Out of the 40 TMPs interviewed, two admitted that they confirm their suspicions through laboratory testing. Other symptoms from which they diagnose TB include, weight loss, general weakness, loss of appetite and night sweats among others.

5. Discussion

5.1. Plant knowledge

Our results show that TMPs in the central part of Uganda use many plant species (90) to treat tuberculosis. The Informant Consensus factor was high (0.72) which shows that there is less variability in the number of taxa used and medicinal tradition is viewed as well-defined in this community(Ugulu et al., 2009). Families *Fabaceae* and *Asteraceae* had the highest number of plant species followed closely by *Moraceae* and *Rutaceae*. Plant species from both families have been documented for antimycobacterial activity in different reviews (Gautam et al., 2007; McGaw et al., 2008). *Fabaceae* is characterized by the presence of coumarins,

pyrrolizidine and quinolizidine flavonoids (Wink, 2010). The above compounds reportedly have bacterial activity which could justify their relevance in treatment of TB. *Fabaceae*, *Asteraceae* and *Rutaceae* families have also been mentioned by several authors to be most used by local communities (Ugulu et al., 2009; Ssegawa and Kasenene, 2007; Yineger and Yewhalaw, 2007).

Several plant species mentioned by TMPs in this study have been reported for the treatment of TB and other respiratory infections. *Erythrina abyssinica* and *Eucalyptus* species were mentioned in Mexico and Portugal by local communities to be used to treat respiratory tract infections (Canales et al., 2005; Camejo et al., 2003). *Allium sativum* has been mentioned by Green et al. (2010) to be used in the treatment of tuberculosis in South Africa while *Combretum molle* is taken as a juice to treat chest complaints in Kenya (Kokwaro, 1976). *Albizia coriaria*, *Mangifera indica*, *Callistemon citrinus, Psedospondia microcarpa, Carica papaya* are used in other parts of Uganda for treatment of tuberculosis and cough (Tabuti et al., 2010; Asiimwe et al., 2013; Namukobe et al., 2011; Ssegawa and Kasenene, 2007). This corresponding use of the same species from different localities is one indication that the species may be efficacious for the treatment of TB.

This study shows that there is a weak positive correlation between plant knowledge with age. This observation differs from studies done by Ugulu et al. (2009) and Guimbo et al. (2011) who reported that generally, knowledge increases with age. In the African tradition, indigenous knowledge especially about usage of plants for healing is transferred orally from one generation to the next and our results show that this transmission is being interrupted.

5.2. Pharmacological validation and phytochemistry

Some of the plant species that have been mentioned by more than ten TMPs in this study have been pharmacologically validated for TB efficacy; these include *Combretum molle*, *Erythrina abyssinica* and *Callistemon citrinus* (Bunalema et al., 2011; Lall and Meyer, 1999; Newton et al., 2000). Others include: *Toddalia asiatica*, *Lantana camara*, *Vernonia amygdalina*, *Allium sativum*, *Aloe vera*, *Azadirachta indica*, *Bidens pilosa*, *Carica papaya*, *catharanthus roseus*, *Centella asiatica*, *Cinnamomum zeylanium*, *Mangifera indica*, *Zingiber officinale*, *Maytenus senegalensis* and *Eucalyptus* spp. (Mariita et al., 2010; Gautam et al., 2007; Newton et al., 2000; Green et al., 2010). This verifies the use of such plants in the treatment of TB in these communities.

Although crude extracts of the above mentioned plants have significant antimycobacterial activity, a few have had their compounds isolated and their minimum inhibitory concentrations (MIC) against *Mycobacterium tuberculosis* documented. Phytochemical analyses from previous studies have characterized ellagitannin punicalagin from *Combretum molle*, allicin from *Allium sativum* and anthraquinone glycosides known as aloin from *Aloe vera* (Asres et al., 2001; Delaha and Garagusi, 1985; Gupta et al., 2010). These compounds have been tested on different strains of *Mycobacteria* and found to be active. Tubercular efficacy of two of the most mentioned plant species, *Zanthoxylum leprieurii* and *Piptadeniastrum africanum* has not been reported and will be the focus of the second phase of this research.

5.3. Plant preparation and dosages

Leaves are the most used parts in the preparation of concoctions. This is a good practice in as far as sustainability is concerned, because leaf harvesting is less destructive to plants compared to harvesting the root bark or stem bark Hamilton and Hamilton (2006).

Herbal medicines were mostly prepared as decoctions and involved mixture of between two to twenty five plant species. This is advantageous in that some phytochemicals aid in neutralizing toxicity, others may increase bioavailability, while others synergistically enhance and complement therapeutic efficacy.

There were variations in the dosages between different TMPs. This is a common practice among TMPs and suggests that the healers are not sure about the doses themselves. This underscores the need to determine effective doses both in vitro and in vivo so as to advise healers about the best dose. In addition, this suggests that TMPs need to be trained on how to standardize their formulations. The use of *Eucalyptus* spp and *Bidens pilosa* as preservatives can be justified by studies by Takahashi et al. (2004); Reichling et al. (2011) and Depa et al. (2007). These studies show that the two plant species are effective against food poisoning bacteria.

5.4. Knowledge on tuberculosis

In developing countries, the lifetime risk of developing active tuberculosis once infected with HIV, is tenfold more than when not infected (Kuete et al., 2010). In Uganda, 50% of TB patients are infected with HIV and 30% of AIDS related deaths are attributed to TB (Ministry of Health, 2010). HIV AIDS was mentioned by more than half of the respondents to be closely associated with tuberculosis in this study. The symptoms of TB that were mentioned by TMPs in this study are not different from those documented to be associated with the disease clinically. However though this is true there is need to bridge the gap between traditional medicine and conventional medicine in Uganda. One TMP mentioned that when they write referral letters to hospitals, these are ignored by medical personnel.

6. Conclusions

Plant based therapies for treatment of TB have been identified in this study. TMPs are knowledgeable about the signs and symptoms of TB and how it is transmitted. However since most plant species mentioned in this study have not been pharmacologically validated, further investigations concerning safety and efficacy of these plants is appropriate as these, may be developed into new drugs to curb the resistant strains of TB.

Acknowledgements

We would like to acknowledge Carnegie cooperation through RISE-AFNNET (Regional Initiative in Science and Education-African Natural products Network) for funding this work. We thank TMPs from PROMETRA who provided us with this information. We appreciate the Uganda National Council of Science and Technology for granting us permission to conduct this study. We acknowledge Mr. Aloysious Lubega for the support he gave us in collecting and preparation of Voucher specimen.

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