DOCUMENTATION, ANTIMYCOBACTERIAL ACTIVITY, AND PHYTOCHEMICAL PROFILING OF SELECTED MEDICINAL PLANTS USED BY THE JAKUN COMMUNITY IN JOHOR

SITI FATIMAH BINTI SABRAN

A thesis submitted in fulfillment of the requirement for the award of the Doctoral of Philosophy of Science

Faculty of Science, Technology and Human Development
Universiti Tun Hussein Onn Malaysia

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DEDICATION

For my late abah (Tuan Hj. Sabran Hj. Adnan) who taught me that plants can make wonders if we treat them with patience and passion. For my beloved mak (Puan Misarah Hj. Ahamad), who is also an unsung fighter, for her prayers, unconditional love, support and understanding throughout these years. She has been a constant source of encouragement and an inspiration to me. Also, for my siblings (Wahedah, Jamaluddin, Aishah and Zaharah) who always be with me during thick and thin. May Allah bless and grant them Jannah.
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ABSTRACT

Tuberculosis (TB) is a major threat to human health due to its increasing global epidemiology and emerging drug-resistant strains. While traditional knowledge (TK) could be a tool for development of novel TB treatment, TK itself is at verge of loss due to modernization and deforestation. The objectives of the study were to document the TK of medicinal plants used for the treatment of TB and its related symptoms as practiced by the Jakun community of Kampung Peta, situated in Taman Negara Johor Endau Rompin; to investigate the antimycobacterial activity and mechanism of action of the selected medicinal plants extracts; and to profile their major phytochemical constituents. Documentation of TK were analyzed qualitatively from semi-structured interviews. Among 23 species documented, water and organic crude extracts of selected plants were evaluated for their antimycobacterial activity using agar disk diffusion, resazurin microplate assay, and agar plate assay against Mycobacterium smegmatis. Upon treatment with the active crude extracts, mechanism of action was investigated via time-kill analysis, leakage of compounds absorbing at 280 nm, field emission-scanning electron microscopy, and 2D proteomic analysis. Findings showed that ethyl acetate extract of Thottea grandiflora displayed the largest inhibition zone (DIZ= 14.92 ± 0.86 mm). Hexane extracts of Dipterocarpus sublamellatus and Tetracera macrophylla showed the lowest minimum inhibition concentration (MIC= 0.78 mg/mL). Ethyl acetate extract of T. macrophylla, and both hexane extracts of D. sublamellatus and T. macrophylla showed the lowest minimum bactericidal concentration (MBC= 3.13 mg/mL). At 4-fold of MIC, ethyl acetate extract of T. macrophylla killed the bacterial cell within 8 hours of treatment by multitarget mechanisms such as inhibition of protein and cell wall synthesis and disruption of metabolic processes. Using gas chromatography- mass spectrometry (GC-MS) analysis, pyrazole and phenanthroline derivatives were detected as among the major constituents that potentially contribute to the antimycobacterial activity. The results scientifically validated the plants used in Jakun’s traditional medicine displayed promising therapeutic properties and further studies in this direction could lead to the discovery of multitargets antimycobacterial agents.
ABSTRAK

Tuberkulos (TB) ialah ancaman utama kepada kesihatan manusia kerana epidemiologi global yang semakin meningkat dan kemunculan strain rintangan ubat. Walaupun pengetahuan tradisional (TK) mampu menjadi wadah untuk pembangunan rawatan TB, TK sendiri semakin menghilang akibat pemodenan dan penebangan hutan. Objektif kajian ini adalah untuk mendokumentasi TK bagi tumbuhan ubatan yang digunakan untuk rawatan TB dan gejala-gejala yang berkaitan seperti yang diamalkan oleh masyarakat Jakun di Kampung Peta, Taman Negara Johor Endau Rompin; untuk menyiiasat aktiviti antimikobakteria dan mekanisme tindakan daripada ekstrak tumbuhan ubatan terpilih; dan untuk memprofiil kandungan utama fitokimia mereka. Pendokumentasian TK dianalisis secara kualitatif daripada temu bual separa berstruktur. Antara 23 spesies yang didokumenkan, ekstrak kasar air dan organik bagi tumbuhan terpilih dinilai untuk aktiviti antimikobakteria melalui penyebaran agar cakera, asai plat mikro resazurin dan asai plat agar terhadap Mycobacterium smegmatis. Setelah dirawat dengan ekstrak kasar yang aktif, mekanisme tindakan disiasat melalui analisis masa pembunuh, kebocoran sebatian yang diserap pada 280 nm, medan pancaran imbasan mikroskop elektron, dan analisis proteomik 2D. Dapat ditemui bahawa ekstrak etil asetat Thottea grandiflora menunjukkan diameter zon perencatan terbesar (DIZ = 14.92 ± 0.86 mm). Ekstrak heksana Dipterocarpus sublamellatus dan Tetracera macrophylia menunjukkan kepekatatan perencatan minimum yang paling rendah (MIC = 0.78 mg/mL). Ekstrak etil asetat T. macrophylia dan kedua-dua ekstrak heksana D. sublamellatus dan T. macrophylia menunjukkan kepekatatan bakteriasid minimum yang paling rendah (MBC = 3.13 mg/mL). Pada 4 kali ganda MIC, ekstrak etil asetat T. macrophylia membunuh sel bakteria dalam masa 8 jam rawatan melalui mekanisme sasaran pelbagai iaitu perencatan sintesis protein dan dinding sel serta gangguan proses metabolik. Melalui analisis kromatografi gas–pektrometri jisim (GC-MS), derivatif bagi pyrazola dan phenantrolin dikesan sebagai komponen utama yang menyumbang kepada aktiviti antimikobakteria. Hasil kajian telah mengesahkan secara saintifik bahawa tumbuhan yang digunakan dalam perubatan tradisional masyarakat Jakun memaparkan ciri terapeutik dan mampu membawa kepada penemuan agen antimikobakteria dengan sasaran pelbagai.
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<td>4 fold of</td>
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<tr>
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<td>$n$ equal to $x$</td>
</tr>
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<tr>
<td>CFU</td>
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<td>microliter</td>
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<td>ABS</td>
<td>Access and Benefit Sharing</td>
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<td>Asia Indigenous Peoples Pact</td>
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<tr>
<td>AODC</td>
<td>Albumin, Oleic acid, Dextrose, and Catalase</td>
</tr>
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<td>APS</td>
<td>Ammonium persulfate</td>
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<td>ATCC</td>
<td>American Type Culture Collection</td>
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<td>BCA</td>
<td>Bicinchoninic Acid</td>
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<td>BRIMAS</td>
<td>The Borneo Resources Institute</td>
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<td>CBD</td>
<td>Convention on Biological Diversity</td>
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<td>CE</td>
<td>Common Era</td>
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<td>COG</td>
<td>Cluster of Orthologous Groups</td>
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<td>CSIR</td>
<td>Council of Scientific &amp; Industrial Research</td>
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<td>DIZ</td>
<td>Diameter of inhibition zone</td>
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<td>Dimethylsulfoxide</td>
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<td>Field Emission- Scanning Electron Microscopy</td>
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<td>GC-MS</td>
<td>Gas Chromatography- Mass Spectrometry</td>
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<td>Global Positioning System</td>
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<td>GTP</td>
<td>Guanosine triphosphate</td>
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<tr>
<td>HDS</td>
<td>Hexane root extract of <em>Dipterocarpus subamellatus</em></td>
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<td>HTM</td>
<td>Hexane root extract of <em>Tetracera macrophylla</em></td>
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<td>IEP</td>
<td>Isoelectric Point</td>
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<td>Isoniazid</td>
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<td>IUCN</td>
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<td>International Work Group for Indigenous Affairs</td>
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<td>MBC</td>
<td>Minimum bactericidal concentration</td>
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<td>National Key Economic Area</td>
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<td>OD</td>
<td>Optical density</td>
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<td>PIC</td>
<td>Prior Informed Consent</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<td>Sarawak Biodiversity Center</td>
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<td>SDS-PAGE</td>
<td>Sodium Dodecyl Sulfate-Polyacrylamide Gel Electrophoresis</td>
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<td>Tetramethylethylenediamine</td>
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CHAPTER 1

INTRODUCTION

1.1 Introduction

This thesis describes the process of documenting traditional knowledge (TK) of an indigenous group called Jakun, living in Kampung Peta, Johor. The knowledge documented focused on the use of medicinal plants in the treatment of tuberculosis (TB) and its related symptoms. The thesis then further describes the scientific efforts to justify claims made by the Jakun people on the potential of these plants. These were carried out using standardized antimycobacterial tests against a model organism of TB strain and chemical procedures to screen selected plants extracts. Promising findings were successfully established, which demonstrate the capability of TK approach in searching for novel medications in modern era.

1.2 Background of the study

Traditional Knowledge (TK) is a combination of ancient indigenous practices and techniques related to biodiversity, locally adapted, and distinctive to a community in a particular area. It is normally passed on orally through generations via daily practices such as folk songs, dances, stories, poetries, carvings and paintings (Lim et al., 2010a; WIPO, 2012a). As a result, from these various combinations of practices a knowledge system developed and is applied in various aspects such as medicines, land management, and agriculture. Definition of TK is further detailed in Chapter 2.

TK possessed by different ethnic groups in Malaysia is important in keeping the multi-ethnic identity of the country (Nijar, 2013). An indigenous community,
called the Jakun, from Kampung Peta, Mersing, Johor, is among the diverse groups who are still strongly practicing their TK with regard to the use of medicinal plants in treatment of various ailments (Chee, 2005). Nevertheless, their reliance on TK in general health care and medicine is declining particularly among the younger generations. The improving socio-economic status and the convenient accessibility to modern medicine are seen as probable factors in the declining use of TK (Seow et al., 2013). Additionally, the knowledge possessed by the older folks are decreasingly passed on to the younger generation (Haruyama & Maryati, 2004). This knowledge is now at the threshold of being endangered, and eventually feared to lead to extinction (Christensen, 2002; van Wyk & Wink 2004). Therefore, by conducting proper documentation, existing TK could be maintained, not easily manipulated, and could prevent erosion of TK as it is one of Malaysia’s priceless national heritage.

Documentation is a process of collecting, recording, and keeping data systematically until the available information can be used for future references (WIPO, 2013). Some early-civilized ethnics of the world, such as the Chinese and the Indians, have demonstrated how systematic and proper documentation of TK benefit future necessities. The written version of their traditional medicine is well-kept in the form of medical pharmacopeia and the systems are formally called as Traditional Chinese Medicine (TCM) (Quah, 2003) and Ayurveda (Pawrdhan, 2005). In contrast, for the local or indigenous Malaysian ethnics, the knowledge of traditionally used medicinal plants species remain insecured since they only keep and transfer the knowledge through verbal transmission and informally adapting it as their way of life. In recent times, government agencies of Malaysia initiate endless efforts to document the knowledge through publications such as Malaysian Herbal Monograph and Compendium of Medicinal Plants Used in Malaysia (Jantan, 2004). In addition, there is also an effort to create an integrated database such as the Global Information Hub on Integrated Medicine (Globinmed). These act as a starting point to encourage advance researches that could provide scientific evidence derived from the documented TK.

This pool of information is also crucial in searching for new leads in pharmaceutical, nutraceutical and cosmeceutical industries. The knowledge are awaiting to be explored amongst the richness of biological diversity of Malaysian tropical rainforest. With this information, the position of the government to protect the
indigenous people through Access and Benefit Sharing (ABS) would be further strengthened, giving not only protection but outstanding recognition to the knowledge owned by different ethnic groups in Malaysia. Moreover, these strategies are in-line with the National Key Economic Areas (NKEA), which identify herbal research and development as one of the 12 key sectors to be promoted to turn Malaysia into a high economic country by the year 2020 (MOA, 2013). Globally, about 70% of the world population still relies on traditional medicine as their primary source of healthcare and at least 48% of developed nations has practice it as an alternative medicine (WHO, 2002). The increasing need of natural-based prescriptions in modern societies has been proven. Within 1999 to 2001, global annual market sales of herbal medicines reported that USD 1,005.68 billion were generated while Malaysia generated RM 4.55 billion (USD 1.2 billion) of income through its local trade (WHO, 2005).

There is a growing interest in Traditional and Complementary Medicine (T&CM) and it is now widely accepted in the medicinal and healthcare systems in Malaysia (Silvanathan & Low, 2014). Since 2007, a total of nine integrated hospitals in Malaysia have been adopting and practicing some forms of T&CM under their special departments. Among others, Putrajaya Hospital (Putrajaya), Sultan Ismail Hospital (Johor Bahru), and Kepala Batas Hospital (Pulau Pinang) are practicing Malay massage, Malay post-natal treatment, acupuncture, and herbal therapy as an adjunct treatment for cancer patients (T&CM Division, 2011). Since Malaysia is a mega-biodiversity country and has numerous different ethnics, it would be beneficial to tackle this TK and develop them into modern-day application.

Tuberculosis (TB) is one of the most important chronic respiratory and infectious diseases in the world and in Malaysia (WHO, 2014a). It remains a key global health problem. In 2012, an estimated 8.6 million people developed TB and 1.3 million died from it (WHO, 2014a). In addition, one third of the world population is suspected with latent TB (WHO, 2014a). South-East Asia is the major contributor to TB cases worldwide, of which 29% of TB cases come from this region (WHO, 2014a). TB is an ancient, airborne infectious disease, and principally caused by Mycobacterium tuberculosis (Family: Mycobacteriaceae). The strain uniquely diverged from Gram positive members due to the presence of mycolic acids coating at the cell wall (Smith, 2003). Occurrence of multi-drug resistant tuberculosis strains (MDR-TB) and extensively-drug resistant tuberculosis strains (XDR-TB) pose serious threat to the
current situation (Gupta et al., 2011). Therefore, the epidemiology of TB shows this
disease can affect a whole community by causing significant mortality and morbidity
to human being (WHO, 2014a).

Johor has the second highest prevalence of TB cases in Peninsular Malaysia,
of which 2000 cases were reported in 2005 until 2011 (MaHTAS, 2012). This is
possibly due to the incoming immigrants who are filling up the need for labor intensive
economic activities and services (Arshad, 2013). Symptoms of TB include productive
cough, chest pain, loss of appetite, unexplained weight loss, fever, night sweats, and
fatigue (MaHTAS, 2012). Fortunately, TB is notable, preventable, and curable.
However, the typical anti-TB drugs (rifampicin, isoniazid, pyrazinamide, ethambutol,
and streptomycin) have caused ruthless side and adverse effects to the patients
(Nissapatorn et al., 2003; Gülbay et al., 2006; Villemagne et al., 2012). The cost of
treating TB per patient by the public health services in Malaysia was approximately
RM 2,750 or USD 920 (Elamin et al., 2008). As compared to lower income country
with the most cases of TB such as Africa, this is significantly costly. An ideal anti-TB
regimen is not yet available to combat the resistant strains of TB and the recommended
treatment regimens are problematic (Zumla et al., 2014). For that reason, the search
for at least one potentially new drug derived from nature should be initiated as
proposed by The Stop TB Strategy (WHO, 2006). Guided by the TK of indigenous
people particularly the Jakun of Kampung Peta, Johor, more discoveries in terms of
plants that are used for treatment of TB and its related symptoms were discussed
further in Chapter 4 and Chapter 5.

Malaysia has been estimated to have more than 2,000 species of medicinal
plants and there are about 200 species being used by different ethnic groups all around
the country for healthcare purposes (Rizwana et al., 2010; Jamal, Ghafar & Husain,
2011; Othman et al., 2011). Within this rich plant diversity are a wide range of
secondary metabolites. These metabolites are produced by plants as a defense
mechanism against animals and microbes attacking them and as reaction to the
vigorous and competitive condition they lived in. There are well-established scientific
proofs about tropical plant secondary metabolites which they are now prescribed as
drugs. Examples such as vincristine (anti-cancer from Catharanthus roseus or
Kemunting cina), reserpine (anti-hypertensive from Rauwolfia serpentina or Indian
snakeroot), and calanolide (anti-HIV from Calophyllum lanigerum or Bintangor)
indicated a bright future that more could be discovered among our local resources. With the increasing of traditional and complementary medicine (T&CM) awareness and the huge reservoir of genetic diversity in Malaysia, more research and development are foreseen in the near future.

1.3 Statement of problems

While many studies have focused on either antimycobacterial screening or the phytochemistry in Malaysia, very little is reported primarily on ethnobotany-driven drug discovery approach. Although, an inspiring study had been conducted to screen anti-TB activity of Malaysian plant species used in traditional medicine (Mohamad et al., 2011), the study only focused on commonly used medicinal plants in spite of culturally significant plants. Furthermore, the increasing rate of TB incidence and prevalence in Malaysia and the erosion of TK among indigenous people are both worrying. Therefore, they are addressed in this study. Factors leading to the increasing TB incidence and prevalence in Malaysia include the high rate of incoming immigrants, lack of compliancy among TB patients, and lack of TB research (MaHTAS, 2012; Arshad, 2013). On the other hand, factors leading to the erosion of TK include the improving socio-economic status (Seow et al., 2013), easy access to modern medicines, and lack of interest from younger generations (Haruyama & Maryati, 2004). Hence, this thesis is a scientific endeavor to integrate a study of ethnobotany, bioactivity, and chemistry that intends to benefit the mankind when future needs for any of these scientific data arise.
1.4 Aim and objectives

This study aimed to conserve TK of local people through scientific corroboration. Hopefully, this area of research would trigger more efforts on plant conservation, development of novel pharmaceutical and nutraceutical products, and strengthen the sense of local identities. This was achieved by the following specific objectives of this study, which are:

(i) to document the TK of medicinal plants used by the Jakun community in Kampung Peta, Mersing, Johor on treatment of TB and its related symptoms (cough, cough with blood, chest pain, weakness, fever, night fever, asthma and joint pain).

(ii) to investigate the antimycobacterial activity and mechanism(s) of action of the selected medicinal plants extracts against *Mycobacterium smegmatis*.

(iii) to profile the phytochemical constituents of the selected plants extracts that potentially contributed to the antimycobacterial properties.

1.5 Contributions of the study

Findings from this study provide scientific evidence of the Jakun’s traditional claims with regards to the uses of medicinal plants to treat TB and its related symptoms. They also provide an overview of the roles of community organizations, indigenous federations, policy, and industry in the way natural resources are controlled and accessed in this community through implementation of Access and Benefit Sharing (ABS). The involvement of local community members in documenting their own TK reflects their needs in sharing this important cultural resource among themselves, transmitting it to future generations and providing incentives for plants conservation. Promising outcomes of antimycobacterial potentials that demonstrate significant effects could also be applied to future projects of anti-TB leads and bioprospecting.
CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews four important fundamentals of this study. Section 2.2 elaborates on terminologies, importance, issues, and recent development of TK. Section 2.3 focuses on previous studies conducted on indigenous people and related concerns about Taman Negara Johor Endau Rompin (TNJER) as the home to the Jakun community. Section 2.4 is comprised of updates on TB epidemiology, current development on its treatment and mode of action, and rationalization on how TK approach could provide clues to TB treatment. Lastly, Section 2.5 reviews previous works on ethnomedicinal plants as a source of antimycobacterial agents from 2006 until 2015.

2.2 Documentation of Traditional Knowledge (TK)

2.2.1 Terminologies

Traditional knowledge (TK) is a multidisciplinary concept that could be described in diverse approaches. Warren et al. (1993) showed earlier research of TK was mainly concerned with anthropology, social development, geography, and culture. More current research of TK are engaged in environmental management, agriculture, ecology, medicines and biodiversity-related knowledge (Agrawal, 1995; Huntington,
1998; Pierotti et al., 2010; Lim et al., 2010a; Abbott, 2014; Huntington, 2015) and its integration into scientific knowledge (Albuquerque, Ramos & Melo, 2012).

Documentation of TK refers to all activities of identification, fixation, and classification aimed at facilitating retrieval from an organized data set, such as paper files, digital databases, archives or libraries (WIPO, 2013) while the process of recording of interviews as part of documentation processes. Thus, products of documentation may include herbarium collections, transcriptions of interviews or voice recordings, recorded films, printed images and field notes or diaries (WIPO, 2013). Therefore, these primary data would be preserved, available for future references, and could be useful in linking up with other field of studies.

The key features of TK can be listed as follows: (i) knowledge or practices; (ii) indigenous or local people, and (iii) passed on orally by generations. Numerous studies have attempted to define TK (for example Huntington, 2005). For Malaysia, Lim et al. (2010a) defines TK as

...a combination of ancient indigenous practices and techniques, locally adapted and distinctive to a community in particular area. It is normally passed on orally through generations via daily practices such as folk songs, dances, stories, poetries, carvings and paintings. (p. 2)

At the international level, CBD (1992) in Article 8 (j) of the convention refers TK as “knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles relevant for the conservation and sustainable use of biological diversity”. The term TK was further defined in Nagoya Protocol (WIPO, 2010) as,

...the content or substance of knowledge resulting from intellectual activity in a traditional context, and includes the know-how, skills, innovations, practices and learning that form part of traditional knowledge systems, and knowledge embodying traditional lifestyles of indigenous and local communities, or contained in codified knowledge systems passed between generations. It is not limited to any specific technical field, and may include agricultural, environmental and medicinal knowledge, and any traditional knowledge associated with genetic resources. (p. 1 Annex)

TK is a term frequently used in the literature, but to date no universal definition of TK have been acknowledged yet (Mugabe, 1999; Berkes, Colding & Folke, 2010) while the argument is still evolving (Abbott, 2014). Literature uses various terms interchangeably to designate TK. For examples: traditional cultural expression, indigenous knowledge, tribal knowledge, local knowledge, traditional ecological
knowledge, ethnobiological knowledge, and ethnobotanical knowledge which refer to the similar meaning as TK, otherwise stated distinctly by the specific objective (Globinmed, 2014). Mugabe (1999) proposed a useful diagram (Figure 2.1) to describe the synonymous yet discrete terms associated with TK- indigenous knowledge (IK) is traditional knowledge but traditional knowledge is not necessarily indigenous. In this thesis, the terms TK, ethnobotanical knowledge, and ethnomedical knowledge are used interchangeably to mean knowledge about plants used by indigenous people in healthcare.

![Traditional Knowledge Diagram](image)

**Figure 2.1:** Indigenous knowledge is a subset of traditional knowledge (Mugabe, 1999).

### 2.2.2 Importance of TK documentation

#### 2.2.2.1 Protection against biopiracy

Biopiracy is simply defined as bioprospecting that occurs without benefit-sharing or the consent of source communities (Torri & Herrmann, 2011; Abbott, 2014). The term is commonly used to help developing countries secure benefits for the communities and the preservation and protection of their rights over their TK for their sources of income, avoiding outsiders to manipulate their economy (WIPO, 2012b). The first serious discussion of biopiracy emerged during the 1990s when United States Patent
on wound healing properties of turmeric powder (*Curcuma longa*) was challenged and found invalid, as further documentation was made available (including ancient Sanskrit texts of India) that demonstrated the claimed invention was actually a known TK (Jayaraman, 1997). Other examples of successful protection of TK documentation against biopiracy are neem (*Azadirachta indica* A. Juss.), basmati rice (*Oryza sativa* Linn.), kava (*Piper methysticum* Forster), ayahuasca (*Banisteriopsis caapi* Mort.), quinoa (*Chenopodium quinoa* Willd.), and hoodia (*Hoodia gordonii* (Masson) Sweet *ex Decne*) (Hirwade, 2010; CSIR, 2015).

Despite the established fact that documentation of TK acts as a fundamental tool to overcome the misappropriations in patent ownership, it also has limitations (Nordin, Hassan & Zainol, 2012; Masango, 2013). Documentation may lead to misuse or unwanted disclosure of TK, the intellectual properties rights (IPR) only belong to those who document or record TK and not necessarily to their traditional holders, and the protection granted to the documented content under the copyright regime has a limited scope (WIPO, 2016). Nordin *et al.* (2012) also argued that the IPR is only designed to protect sacred and undocumented TK, but TK documentation could eventually facilitate biopiracy when patents were granted to innovations based on existing knowledge. The reason is because it is difficult to prove the novelty of TK and who holds the originality.

As an example was the case of Sarawak bintangor (anti-HIV agent) which caught people’s attention in 1998 (BRIMAS, 2001, GRAIN & KV, 2002), when the patent is owned by the National Cancer Institute (NCI), USA, neglecting the recognition for the local people. Prior to these weaknesses, many national and international bodies initiated debates, aiming for better efforts in preservation and protection of TK as has been modelled in Figure 2.2 (Secretariat of the Convention on Biological Diversity, 2011). For Malaysia, Sabah and Sarawak have already established state legal frameworks in relation to obtain PIC (SBC, 2015) and ABS in their respective state (MONRE, 2014). Therefore, documenting TK would prevent misappropriation of TK and successful opposition of hundreds of patent applications filed around the world (McGonigle, 2016).
2.2.2.2 Economic values

TK contributes to development of global economy (Dutfield & Jacob, 2011). The commercialization of TK-based products (i.e. medicinal plants) has increased due to their large scale use in various sectors, such as phytochemicals, pharmaceuticals, nutraceutical, herbal remedies, food supplements, perfumes and cosmetics, and food flavouring agents, which are traded in both local and international markets (Abdul Aziz et al., 2003). Indigenous knowledge derived from plants that have supported the above industries, was estimated at USD 1 billion of global market value (WHO, 2005). On the other hand, Fujisawa & Nakashizuka (2012) documented 11 non-timber forest products used in dye and weaving rituals by the Iban people and the ceremony became iconic ecotourism attraction in Sarawak, which in turn generates yearly income to the state.
It is difficult to assess the size of the market for TK-based products with any degree of accuracy due to the variety of regulations and regulatory categories for T&CM products among countries (Zhang, 1998; WHO, 2013a) and controversial issue of politically-importance bioprospecting among stakeholders (Simpson, Sedjo & Reid, 1996; Mugabe, 1999; Rausser & Small, 2000; Vaz & Agama, 2013). However, available literatures confirm the significant rise in annual market sales of herbal medicine globally. For examples, the output of Chinese *materia medica* was estimated to amount at USD 83.1 billion in 2012, the Republic of Korea annual expenditures on traditional medicine were USD 7.4 billion in 2009, out-of-pocket spending for natural products in the United States was USD 14.8 billion in 2008, and the herbal medicine originated from Ayurveda pharmacopeia of India was estimated to value at USD 149 million in 2000 (WHO, 2013a). In 2012, Malaysia generated total export earnings from timber and timber products (including herbal products) amounted to USD 6.16 billion (MONRE, 2014). At least 500 local plants used by the indigenous peoples were documented to have economic properties (Nicholas & Lasimbang, 2004). Potential cost savings and effectiveness are reasons for individuals to turn to traditional herbal medicine services (Farnsworth et al., 1985; WHO, 2013a; Fyhrquist et al., 2014). These figures reflect the incorporation of TK documentation and other forms of traditional medicine as a key driver to global economy.

### 2.2.2.3 Research and development (R&D) for biodiversity-based areas

The interrelationships between society-environment-health have recently been widely acknowledged (Alves & Rosa, 2007; Butchart et al., 2010). The conservation principle of TK, which is applied in land, forest, and agricultural management, is supported by a large number of studies (Vandebroek et al., 2011). Torri & Herrmann (2011) stated that the sustainable uses of natural resources largely depends on local people knowledge (i.e. community-based conservation). Many researchers, policy makers and global agencies recognized the link between TK and conservation (Aiken & Leigh, 1986; Kumar & Tarui, 2004; Zank & Hanazaki, 2012; Ruiz-Mallen & Esteve, 2013; Vaz & Agama, 2013) and adopted this principle in their conservation mechanisms such as in national parks management (Makwaeba, 2004).
In healthcare sector, TK documentation is the basis of traditional medicine. It is a fact that 70% of the world’s population in developing countries depends on traditional medicine for primary healthcare while 48% of the world’s population in developed nations depends on traditional medicine as complementary and alternative medicine (WHO, 2002). With regard to a broad sense of medicine, many researchers considered ethnopharmacology as one of the approaches to integrate modern and traditional medicine (Pretorius, 1991; Fabricant & Farnsworth, 2001; Basso et al., 2005; Andrade-Cetto, 2011; Dutfield & Jacob, 2011; Gyllenhaal et al., 2012; Quave, Pardo-de-Santayana & Pieroni, 2012). In that manner, ethnopharmacological research tries to understand and provide the pharmacological basis of culturally important plants or preparation used by humans (Gertsch, 2009), displaying the relevance of TK documentation for ethnopharmacological research (Reyes-García, 2010; Heinrich, 2014).

The role of TK documentation in ethnopharmacological research is best illustrated in the discovery and development of drugs from medicinal plants. Almost 50% of active ingredients in prescribed drugs were discovered because of their use in traditional medicine (Pan et al., 2011; Veeresham, 2012), particularly from plant sources (Cragg & Newman, 2013). For an instance, artemisinin or qinghaosu is a WHO-approved antimalarial drug originated from Artemisia annua, which was documented by Ge Hong (284–346 CE) and extensively used for chills and fevers in TCM since Ming Dynasty (Tu, 2011). There is a growing evidence that the contribution of TK documentation to health systems has been immense with the discovery of 122 bioactive compounds from various pharmacopeias (Cragg & Newman, 2013). Therefore, documenting TK would help human maintain their physical well-being and jumpstart novel drug discovery.

2.2.2.4 Survival of local identity

TK is closely related to the survival of identity of indigenous people which goes beyond their political systems, belief systems as well as cultural identity (Tijah, 2004). For example, an infusion of the inflorescence plants known as té from Asteraceae and Lamiaceae, which is taken as a stomachic after difficult digestions and as a treatment for stomach pain, has become the symbol of local identity for Cantabria community in
Spain (Pardo-de-Santayana, Blanco & Morales, 2005). Increasing evidence noted by several authors confirm a loss of TK is rapidly happening such as among Kadazan/Dusun ethnic in Sabah (Haruyama & Maryati, 2004) and the Tsimane in the Amazon abandon their TK (Reyes-García et al., 2014).

Being home to a large number of indigenous groups, Indonesia, Thailand, Malaysia, Laos, Vietnam, and Myanmar in Southeast Asia possess a high number of endangered languages that face the risk of extinction, and it should be noted here that various researchers have shown a positive correlation between linguistic, ethnic and biological diversity (Franco et al., 2015; Hidayati, Franco & Bussmann, 2015). In other parts of the world, for example Australia and Canada, they are facing severe circumstances whereby most of their TK was nearly lost (van Wyk & Wink, 2004).

Since TK is transmitted orally in local language across generations, curbing the loss of TK-related biodiversity also strengthens the local linguistic expressions and cultural practices as demonstrated by the Comcaac (Seri people) of Sonora, Mexico (Wilder et al., 2016). Hence, TK documentation offers to strengthen the identity and ethnicity with ethnomedical system as a driving force (Hurrell & Albuquerque, 2012). Therefore, relating to the Malaysian scenario, the preservation and maintenance of the Orang Asli's culture are seen as fundamental to their existence and identity.

### 2.2.3 Advancement in TK documentation

In contrast to traditional ways in which TK is managed and passed on orally across generations while the old-fashioned way of documenting TK is through *materia medica* and ancient texts which are commonly in native language and occasionally never been released (Sarkar, 2015); modern documentation of TK can be done in the form of databases or archives (Napis et al., 2001; Ningthoujam et al., 2012; Mohd Talkah, Zulkiflee, & Shamsir, 2013; Abbott, 2014;). The information of TK are digitized and searchable database are established such as Natural Products Alert (NAPRALERT), Traditional Knowledge Database Library (TKDL), China Traditional Chinese Medicine (TCM) Patent Database, and Biozulua database (WIPO, 2002). The archives (i.e. TK documentation products) are preserved in museums such as the Smithsonian Center for Cultural Life and Heritage, the Library of Congress and the
Database of Official Insignia of Native American Tribes (DONATI) and deposited in national and international herbaria around the world (Cordell, 2012).

Current documentation guidelines (See: Torsen & Anderson, 2010; WIPO, 2012b) are globally available. On the other hand, techniques for documentation and analysis are also essential for validation. Many studies employed qualitative studies (Fassil, 2003; McLellan, MacQueen & Neidig, 2003; Smylie, Kaplan-Myrh & McShane, 2009; Anuar et al., 2010; Franco, Ghani & Hidayati, 2014; Omar & Putit, 2014) and quantitative studies (Leaman et al., 1995; Andrade-Cetto, 2011; Araújo et al., 2012; Mutheeswaran et al., 2011; Ong & Kim, 2014; Tunde et al., 2014) while only a few studies performed mixed-method (Bruschi et al., 2011; Stekelenburg et al., 2005; Viney et al., 2014). Proper documentation is essential in the 21st century for the preservation and protection of TK (UNCTAD Secretariat, 2005) as well as for the growth of herbal medicine usage (Sen, Chakraborty & De, 2011).

2.2.4 Threats to documentation of ethnobotanical knowledge

The loss of TK is widely reported. TK is eroding in Malaysia (Haruyama & Maryati, 2004) and rapidly lost throughout the world (Kumar & Tarui, 2004; van Wyk & Wink, 2004; Srithi et al., 2009; Reyes-garcía et al., 2014) despite the importance of plants for human health and subsistence in developing and developed nations. The UNCTAD Secretariat (2005) predicted that 90% of TK could be lost within the next 100 years. TK is significantly threatened in many ways. Loss of natural resources (Zuchiwsci et al., 2010; Hanazaki et al., 2013), deforestation (UNCTAD Secretariat, 2005; Lim et al., 2010b), modernization and globalization (Benz et al., 2000; Vandebroek & Balick, 2012), rural-urban migration for education and employment (Kamaruddin & Jusoh, 2008; de Almeida et al., 2011), resettlement of indigenous people and increasingly urbanized society (Napis et al., 2001; Balick, 2007; Gill, Ross & Panya, 2009), cultural homogenization (Rosso & Bäärnhielm, 2012), and rapid development (Ramirez, 2007) are all factors attributed to the general decline in TK. On the other hand, ethnomedical knowledge has been identified as particularly vulnerable to loss globally due to increasing reliance on biomedical healthcare, devaluation of the occupation of traditional herbal practitioner by younger generations, lack of cultural
support, and some governmental policies or programs to revolutionize medical practice, and death of old people (Balick, 2007; Tilburt & Kaptchuk, 2008).

Despite the threats to TK, this valuable entity should be preserved and protected. Hence, this put us in a greater state of urgency to document all of these valuable knowledge before they become extinct. According to Kosciejew (2015), documentation studies help illuminate how information is created, stabilized, and materialized such that it can emerge and, in turn, how it can then be controlled, deployed, enforced, entrenched, managed, and used in many different ways, in various settings, and for diverse purposes. Documentation, in other words, helps transform information into tangible entities that can be employed to shape, guide, and discipline its particular contextual setting.

In summary, TK is a knowledge that is passed down orally across generations that could be applied in various fields accordingly. TK plays a significant role in human healthcare, economic development, local identity, and biodiversity conservation. Recent development of TK documentation involves digitization of knowledge for global dissemination. TK is threatened by biodiversity loss and modernization, highlighting the prominent need for its documentation in order to conserve and preserve what is left in TK.

2.3 Ethnobotany of the Jakuns

2.3.1 The Jakun community in Johor

Globally, indigenous peoples are estimated to be 300 million people, in which more than 90% originated from Asia. While constituting merely 4.4% of the world’s population, they represent between 70 and 80% of the world’s cultural diversity (AIPP & IWGIA, 2010). Definition of indigenous peoples according to Rodolfo Stavenhagen, UN Special Rapporteur for the study of discrimination against Indigenous Peoples (United Nations, 2002) is as the following:

Indigenous communities, peoples and nations [are] those which, having a historical continuity with pre-invasion and pre-colonial societies that developed their territories, consider themselves distinct from other sectors of societies now prevailing in those territories or parts of them. They form at present non-dominant sectors of society and are determined
to preserve, develop, and transmit to future generations their ancestral territories and their ethnic identity as the basis of their continued existence as peoples, in accordance with their own cultural patterns, social institutions and legal systems. (p. 37)

Malaysia is recognized for its multiracial and multicultural identity (Kennedy, 2015; Rajendran & Wee, 2015). Among its 28.6 million population, the Malays (50%), Chinese (22%), and Indians (7%), are the three major ethnic groups. The remaining 12% population consists of 97 sub-ethnicities of indigenous people from Peninsular Malaysia (eastern) and Sabah and Sarawak (western) (Department of Statistics Malaysia, 2012). This racial diversity maintains Malaysia as a mixed Asian cultural society that holds unique languages and TK. With regards to TK, indigenous people are among the people who still maintain their TK practices. For example, indigenous people still use plants in their environment as a source of medicine, food, housing construction, and in ritual (Kardooni, 2014).

Orang Asli is a local term referring to indigenous people specifically in Peninsular Malaysia while the term prabumi specifically refers to indigenous people in Sabah and Sarawak (Rachagan, 1993). Similarly, the term Orang Asli is also denoted to some communities in Krajan, East Java of Indonesia. A total of 18 tribes of Orang Asli, estimated to comprise of 150,000 people, are found distributed all over Peninsular Malaysia and they form about 0.5% of Malaysian population (Department of Statistics Malaysia, 2012). They are classified into three major groups: Negrito or Semang (northern region; 3% of the Orang Asli population), Senoi (middle region, 54% of the Orang Asli population), and Proto-Malay or Aboriginal Malays (southern region, 43% of the Orang Asli population) as shown in Figure 2.3 and Figure 2.4. These classifications are based on morphology, culture, language and geographical locations for the convenience of administration (Masron, Masami & Ismail, 2010; Lim et al., 2010b; Ang et al., 2012; Nicholas, 2012).
Figure 2.3: Three main groups and 18 subgroups of Orang Asli in Peninsular Malaysia

Figure 2.4: Distribution of Orang Asli by ethnic groups in Peninsular Malaysia (Vengadesan, 2009)
The existence of the Aboriginal Peoples Act 1954 (Act 134) under the Aboriginal people Ordinance No. 3, 1954 that was amended in 1974, the setting of terms and qualifications to be recognized as an Orang Asli community has been expounded in detail. Based on Section 3 of the Aboriginal Peoples Act 1954 (Act 134), Orang Asli is defined as follows (JAKOA, 2013b):

(i) any person whose male parent is or was, a member of an aboriginal ethnic group, who speaks an aboriginal language and habitually follows an aboriginal way of life and aboriginal customs and beliefs, and includes a descendent through males of such persons; or

(ii) any person of any race adopted when an infant by aborigines who has been brought up as an aborigine, habitually follows an aboriginal way of life and aboriginal customs and beliefs and is a member of an aboriginal community;

The Orang Asli is a name translated from the term “aborigines” or “originals”, which replaces the old names of Sakai, Orang Darat, Orang Dalam, Orang Asal (Tijah, 2004; Md. Akbal et al., 2009). These terms are given during the British colonial period back in 1940’s to differentiate the Orang Asli with the Malays. Throughout Malaysia’s history, the Orang Asli was seen to play a significant role when their skills in the jungle helped repel guerilla attacks by the communist insurgents (Baer, 2012). As a consequence, for decades, these callings have created negative impression and second-rate stigma in which the Orang Asli are still living in primitive (Manickam, 2015).

There are 11,944 of Orang Asli living in 59 villages all around Johor (JAKOA, 2012), which consists of Jakun, Seletar, Kuala, Temuan, Semelai, and Kanaq (JAKOA, 2013a). With regards to Orang Asli, a tribe called the Jakun, which is a subgroup of Proto-Malay and is the second largest indigenous group in Peninsular Malaysia (Masron et al., 2010). Additionally, the Jakun is the most dominant Orang Asli tribe in Johor (Md. Akbal et al., 2009). In addition, they also referred themselves as Orang Hulu (Davison, 1988; Chew, 2007). The Jakun community are believed to have migrated from southern China to South-East Asia between 3,000 to 5,000 years ago (Hill et al., 2006). They practice animism and each of the Jakun community is led by a Batin (village headman). The Jakun is believed to be the earliest among the indigenous groups to practice agriculture and leaving their hunter-gatherer lifestyle
(Manickam, 2015). The Jakun people customarily speak a dialect that belongs to the same Austronesian family languages which has similarity with the Malay language (Ghazali, Suffian & Shamsudin, 2010; Abd Rahman, 2012). Additionally, their cultures are the closest to the Malays as compared to other group of Orang Asli (Longuet, 2008).

Endau Rompin forest (2°25’12.94”N, 103°15’40.94”E) is one of the few remaining areas of virgin lowland rainforest in the southern part of Peninsular Malaysia. Geographically, it is the main land Asian’s southernmost stretch of tropical rainforest. In 1993, 48,905 hectares of the Endau Rompin forest was gazetted as a national park by the state government of Johor (Chew, 2007). On the other hand, Kampung Peta is a village located outside the boundaries of the park (Figure 2.5). It has become the main entrance to Taman Negara Johor Endau Rompin (TNJER) in the municipality of Mersing, Johor. Within the rich lowland mixed dipterocarp forest of the park lies various species of plants that provide substantial sources for food, medicines, shelters, timber products, and many more to the nearby civilization (Davison, 1988), which in this case is the Jakun.

![Figure 2.5: Location of Taman Negara Johor Endau Rompin and Kampung Peta (Labis District Council, 2015)](image-url)
The Jakun community of Kampung Peta are descendants of the first inhabitants of Endau River valley (COAC, 2015). The population of Jakun community in Kampung Peta is about 220 people with 67 households, which represents 2% of the whole Orang Asli in Johor (JAKOA, 2012). They are still practicing traditional lifestyle amidst modern facilities and strongly adhere to their ancestors beliefs as their way of life (Mohd Sam & Seow, 2014). They speak the Jakun dialect which is a sub-dialect of the Malay language. Their livelihood relies heavily on natural resources around them, which includes combination of fishing, hunting, farming, and trading forest products. Recent years have shown tremendous changes in their lifestyle. Due to socioeconomic improvement, the younger generation of Jakun are able to get higher education and many have migrated to other places (Seow et al., 2013).

2.3.2 Ethnobotanical studies about Jakun community

The first documentation work about medicinal plants used by the Jakun community in Kampung Peta recorded 52 plants species used for minor common ailments (Taylor & Wong, 1987). Additionally, 118 species of plants from TNJER were also surveyed against their alkaloid, saponin, triterpene, and steroid contents (Kiew et al., 1987). Recent inventory data taken from 2005 to 2008 showed that approximately 54 nontimber plant families are used for various ethnobotanical uses that include Rubiaceae (16 species), Arecaceae (12 species), Annonaceae (9 species), Melastomataceae (7 species), Euphorbiaceae (5 species), Leguminosae and Zingiberaceae (4 species), and Conneraceae, Liliaceae, Myrtaceae, Rhizophoraceae, and Piperaceae (3 species) (Chee, 2005; Khazanah Endau Rompin–Herba, 2007, Khazanah Endau Rompin- Herba, 2008). On the other hand, the Jakun community in Kampung Selai, which is the other entrance for TNJER, was documented to use 41 species of medicinal plants for various ethnobotanical uses; but also noted that they might utilize up to 200 species of plants (Ong, 2005). This information demonstrates the prominence and dependency of the Jakun community on such plants that may have potential value as sources of active medicinal principles.

Although the Jakun community in Kampung Peta still depend on their ethnomedical knowledge for primary healthcare, it is easy to lose this attribute as the world progresses towards modernization. Therefore, by conducting proper
documentation, existing ethnomedical knowledge could be maintained and not easily manipulated. While no previous ethnomedical study had been conducted specifically for the treatment of TB from this community, the new information gained from this study might initiate further studies to aim at exploring the anti-TB potentials or antimycobacterial properties of the plants, supporting the sustainability of traditional herbal medicine in local community and conserving plants diversity. In comparison, the documentation about medicinal plants used by the Jakun community is still in its preliminary stage as compared to other Orang Asli tribes such as the Temuan (Mat-Salleh, Kusalah & Latiff, in press).

2.3.3 Status of ethnobotanical knowledge documentation in Malaysia

Malaysia is ranked as the twelfth mega diverse country in the world due to its richness and endemism of flora and fauna (CBD, 2015). Recognizing this uniqueness, ethnobotanical knowledge of medical documentation in Malaysia has been conducted since 1897 by Ridley through his writings titled “Malay Materia Medica” (Ridley, 1897). Next, Gimlett & Thomson (1939) and Burkill (1966) produced two popular manuscripts entitled and “A Dictionary of the Malayan Medicine” and “A Dictionary of the Malayan Economic Products”, respectively. Presently, although there are several local universities and institutions involved in TK documentation, the reports are only available in the institutions where they were submitted to and not easily available for public reference (Mat-Salleh, Latiff & Nazre, 2001). Based on a general survey conducted by Universiti Kebangsaan Malaysia (UKM), approximately 60% of the TK documentations were in the form of theses while less than 30% of the TK documentation were published in journals, books, and monograph (Mat-Salleh et al., in press) testifying that Malaysian ethnomontanists are still lacking in terms of publications.

In general, native herbal practitioners in Malaysia recognize and utilize at least 100 species of plants while the whole indigenous community could utilize at least 200 species of plants (Ong, 2005). Several studies pertaining to documentation of ethnobotanical knowledge about medicinal plants in Malaysia had been published as journal articles (Table 2.1).
Table 2.1: Summary of ethnobotanical knowledge documentation in Malaysia from 2005 to 2015 for treatment of various ailments

<table>
<thead>
<tr>
<th>Ethnics</th>
<th>Number of plants</th>
<th>Symptoms and complaints</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temuan</td>
<td>47</td>
<td>General</td>
<td>Azliza et al., 2012;</td>
</tr>
<tr>
<td></td>
<td>69</td>
<td>General</td>
<td>Ong, Chua &amp; Milow, 2011;</td>
</tr>
<tr>
<td></td>
<td>44</td>
<td>General</td>
<td>Ong, Lina, &amp; Milow, 2012</td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>General</td>
<td>Ong, Ahmad &amp; Milow, 2011</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>Malaria</td>
<td>Chee, 2005</td>
</tr>
<tr>
<td>Jakun</td>
<td>50</td>
<td>General</td>
<td>Ismail et al., 2015</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td>General</td>
<td>Alsa'arhan et al., 2012</td>
</tr>
<tr>
<td>Seletar</td>
<td>157</td>
<td>General</td>
<td>Norini et al., 2013</td>
</tr>
<tr>
<td>Semelai</td>
<td>16</td>
<td>General</td>
<td>Lin, 2005</td>
</tr>
<tr>
<td></td>
<td>53</td>
<td>General</td>
<td>Ong, Faezah &amp; Milow, 2012</td>
</tr>
<tr>
<td>Semai</td>
<td>37</td>
<td>General</td>
<td>Ong, Lina &amp; Milow, 2012</td>
</tr>
<tr>
<td>Temiar</td>
<td>97</td>
<td>General</td>
<td>Norini et al., 2013</td>
</tr>
<tr>
<td>Kensi</td>
<td>39</td>
<td>General</td>
<td>Mohammad, Milow &amp; Ong, 2012</td>
</tr>
<tr>
<td>Jahai</td>
<td>97</td>
<td>General</td>
<td>Norini et al., 2013</td>
</tr>
<tr>
<td>Batek</td>
<td>200</td>
<td>General</td>
<td>Abdullah et al., 2014; Alias &amp; Salleh, 2014</td>
</tr>
<tr>
<td>Semang</td>
<td>62</td>
<td>General</td>
<td>Samuel et al., 2010</td>
</tr>
<tr>
<td>General</td>
<td>34</td>
<td>Malaria</td>
<td>Al-Adhroey et al., 2010</td>
</tr>
<tr>
<td>General</td>
<td>19</td>
<td>TB</td>
<td>Mohamad et al., 2011</td>
</tr>
</tbody>
</table>

Recent trend based on the literature shows that ethnobotanical knowledge documentation is increasing from 12 publications in 1999 (Mat-Salleh et al., in press) to 19 publications. To date, no documentation of TK has been published on other tribes of Orang Asli such as Kuala, Kanaq, Che Wong, Semoq Beri, Temoq, Mah Meri, Kintaq, Lanoh, and Mendriq. The recent studies showed that the ethnobotany of Temuan is still favored despite the fact that TK documentation had been conducted comprehensively on the Temuan tribe. Ethnobotanical studies would have been more useful if they had focused on other indigenous community in Malaysia as what had been suggested by Mat-Salleh et al. (in press). Additionally, most of the reported studies merely concern about general healthcare with unspecified disease and lack of emic perceptions to reflect the true philosophy of the ethnomedical knowledge of an indigenous people community. Furthermore, most TK-related studies from Malaysia are still dealing with documenting plant uses or Phase 1 in ethnobiology as similar to other Southeast Asia countries (Hidayati et al., 2015). On the other hand, several prototypes have been developed based on TK-documentation studies such as using an ethnobotanical plant (family Malvaceae) used by the Semelai with anti-diabetic properties (FRIM, 2014).
In summary, the Jakun community in Johor, particularly in Kampung Peta has many things to offer with regards to their TK of medicinal plants. This community have a direct access to the oldest tropical rainforest of the world, which is the Endau Rompin forest, as their home and coexist together with of many rare plants, insects, and other organisms. Noteworthy is the fact that many more plants and animals have not yet been catalogued, not to mention the potential chemical and pharmacological principles that they may contain and bring countless benefits to all mankind. The reviewed literature are only to provide an overview of indigenous knowledge in Peninsular Malaysia with an effort to provide an insight that our TK has not been fully documented.

2.4 Tuberculosis (TB) disease

2.4.1 Epidemiology of TB

TB is the world’s second leading cause of death from infectious disease, after HIV/AIDS (Frieden et al., 2003; WHO, 2015). In 1993, TB was declared as a global health emergency (WHO, 2002a) and still remains as the world’s greatest threat (WHO, 2014a). The global prevalence of this primitive, airborne disease was estimated to be 13 million in 2014 (WHO, 2015), which is one-third of the world’s population, showing a slight increase as compared to 11.2 million in 2013 (WHO, 2013b). In 2014, 9.6 million people were reported to develop active TB and 1.5 million people died from it (WHO, 2015) with more than 50% of the cases were co-infected with HIV. Its epidemiology shows that this disease can affect a whole community by causing significant mortality and morbidity to human being (Murray et al., 2014). Table 2.2 shows the global distribution of TB divided amongst seven regions.
REFERENCES


