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Thai Ethnomedicinal Plants Used for Diabetes Treatment

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Abstract:

***Background*:** Diabetes is a metabolic disorder and a serious global health problem. Over 400 million people suffer from diabetes and it is estimated that the number will dramatically increase in the future. The cost of diabetes treatment for individual patients is very high. However, traditional knowledge could be used to support conventional diabetes treatments. Here, we identify medicinal plants that have been used as treatments for diabetes based on Thai ethnobotanical knowledge.

***Methods*:** We present a literature review of data for the use of ethnomedicinal plants for diabetes treatments used by people in Thailand. The data were obtained from 31 original references including theses, reports, journal articles, and books published from 1992–2015.

***Results*:** In total, 187 reports of 123 plants species that had been used traditionally to treat diabetes in Thailand were identified. *Tinospora crispa* (L.) Hook. f. & Thomson, *Morinda citrifolia* L. and *Phyllanthus amarus* Schumach. & Thonn were the three most commonly used species. There were also numerous reports of the use of Leguminosae, Lamiaceae, Phyllanthaceae, Rubiaceae, and Acanthaceae for the treatment of diabetes. Interestingly, the grass family (Poaceae), for which there were otherwise few medicinal use reports, ranked third in our data. Stems, roots, and leaves were most commonly used in diabetes

medicinal recipes. For preparation and administration of the diabetes medicines, decoction and oral ingestion were most common.

***Conclusions*:** Thailand has a vast number of plant species that have been used by ethnic minority groups and rural Thai communities in traditional medicines to treat diabetes. These plants constitute a potentially important natural resource to provide inexpensive treatment of a disease commonly affecting the population of Thailand. The plants used for diabetes treatment should be tested for pharmacological efficacy to help select the most useful for traditional medicines.

Keywords

Medicinal plants; *Tinospora crispa*; *Morinda citrifolia*; *Phyllanthus amarus*; Thailand; traditional medicines

1. Introduction

Diabetes mellitus is a chronic metabolic disorder caused by the inability to control blood sugar levels via the hormone insulin [1]. Diabetes is associated with a variety of long-term effects, including damage to the blood vessels, causing eye problems, sores and infections, reduced capacity to control blood pressure and cholesterol, nerve damage and associated pain [1]. There are three major types of diabetes. Type 1 diabetes, which accounts for 5% to 10 % of all cases, is caused by the inability of the pancreas to produce insulin [2]. In Type 2 diabetes, which accounts for 90% of all cases, the pancreas generally produces insulin, but the target cells cannot receive the insulin signal or sometimes, the pancreas does not produce enough insulin [3]. Finally, gestational diabetes occurs in pregnant women, especially during the third trimester [4]. Diabetes is one of the world's most serious concerns as a major non-epidemic health problem. On a global scale, the number of cases increased dramatically from 108 million in 1980 to 422 million in 2014 [5] and is expected to reach 629 million in 2045 [1]. In terms of the geographic distribution of diabetes cases in 2017, there were 159 million in the western Pacific, 82 million in South Asia, 58 million in Europe, 46 million in North America and the Caribbean, 39 million in the Middle east and North Africa, 26 million in South and Central America, and 16 million in Africa [1]. Based on the predictions, the global number of diabetes cases will increase with 48% by 2045. Africa, Middle east and North Africa, and South Asia will be the areas with highest increases of 156%, 110%, and 84%, respectively [1].

There are several medicinal treatments for diabetes. However, their costs are usually high [6]. More than 146 million people with diabetes live in rural areas and most deaths occur in poor countries [1] where there are fewer opportunities to access effective treatments. Nevertheless, traditional treatments, such as artemisinin, show promise as alternative or supplementary treatments for a variety of conditions. Artemisinin, which is obtained from *Artemisia annua* L., was identified as an effective treatment for malaria in traditional Chinese medicine by screening plants [7]. Another ethnobotanical study in Mexico revealed traditional medicinal plants that were effective in the treatment of diabetes [8]. Consequently, ethnomedicinal knowledge is an invaluable source of medicines, especially in deprived rural areas.

Thailand's population includes a large number of ethnic groups [9] as a result of historic migration from neighboring countries. These groups represent a rich source of important traditional knowledge. In this study, we analyzed the data in reports of plants used for traditional treatments of diabetes in Thailand. These data were extracted from a larger data-set obtained from studies of traditional medicine in Thailand. The larger data-set was extracted from 64 references published from 1990 to 2014 and accounted for 16,789 reports of use referring to 2,187 medicinal species used in 121 villages throughout Thailand and inhabited by 26 ethnic groups [10]. The original large dataset consisted of ethnomedicinal use by ethnic minority groups (*Lua, Khamu, Lue, Sakai, H'tin, Taiyai, Haw, Kachin, Moken, Phuthai, Musue,* the so-called northern Thailand hill tribes *Karen, Hmong, Mien, Akha, Lisu, Lahu*), as well as individuals who do not belong to an ethnic minority (designated as Rural Thai). These groups were divided into seven sub-groups according to geographical regions [11]. Many of the ethnic minority groups surveyed in our general ethnomedicinal review lived in remote areas with poor access. Of the original list of 64 reviewed references, 31 included information on plants used in traditional diabetes treatments in Thai ethnomedicine (Appendix 1). In our analysis, we investigated the following: 1) the number of plant species used in Thailand to treat diabetes; 2) the identity of the most frequently used plant species and families; 3) the parts of plants used in local formulations to treat diabetes; and 4) the methods used to prepare and apply the medicine for the treatment of diabetes. Elucidation of these issues will facilitate the identification of plant species that can be used for the effective treatment of diabetes patients.

2. Materials and Methods

This study is based on previously published references; therefore, there are no ethics issues referring specifically to the study.

Reports of ethnomedicinal uses were obtained from 31 references (1 book, 11 journal articles, 1 scientific report, and 18 theses) published from 1992 to 2015 and including data relating to traditional treatment of diabetes in Thailand (Appendix 1). The scientific report is not available online but hard copy is available from the author's institution. The report by Phumthum et al. provides details of the method used to avoid repeated inclusion of data cited in multiple references [10]. Our main source was from master and PhD students' theses and mostly the journal papers that were derived from the same study were not included. For example, information in the thesis from the reference no [12] subsequently appeared in three journal articles (the reference no. [13], [14], and [15]), but only use reports mentioned in the thesis were databased because all reports from the subsequent articles were the same as those mentioned in the thesis. All theses that included ethnobotanical information submitted to Thai universities and higher educational institutes were searched using the Thai Library Integrated System (www.tdc.thailis.or.th). We searched for the relevant information based on thesis title, year and institute. We also searched for other research articles using the keywords "ethnobotany" and "medicinal plants" and "Thailand" in the Google scholar and Scopus databases. We also searched all Thai scientific journals in both Thai and English languages. Although some of the studies listed in Appendix 1 appear to cover the same sites, they were confirmed to be distinct. For example, the studies reported by Inta et al (2013) and Ponpim (1996) [16, 17] were both conducted in Chiang Dao district, but one was in Ban Hua Thung subdistrict and the other in Muangna subdistrict. The

studies reported by Chuakul et al. (2002a) and Chuakul et al. (2002b) [18, 19] were based on fieldwork in Yasothon Province, but one was conducted in Kutchum district and the other in Loengnoktha district. Reports of ethnomedicinal use were included only when the scientific names of the plant were included as well as the sources of information such as informants, villagers, and ethnic population. To avoid replication of plant use reports, many sources of information that specified only the use and scientific names of plants, and studies such as some pharmacological or plant biological studies that did not specify the sources of information, were excluded from this study. The ethnomedicinal use reports from the original references were collected following ethnobotanical standard protocols stated in each original reference (see list of references in Appendix 1). Each use report consisted of the plant's scientific name standardized to follow *The Plant List* (www.theplantlist.org), plant family, plant part used, preparation, application, and the ethnic group that use that plant. The database included information derived from 11 groups consisting of 10 ethnic minority groups and the Rural Thai group, which is not considered an ethnic minority.

3. Results

The information about plants used to treat diabetes in the 31 references in this study, were obtained from 44 villages and 11 ethnic groups. The highest number (21) of villages from which information was available were represented by the Rural Thai group. Relevant information for the *Karen, Hmong, Mien,* and *Lua* ethnic minority groups were obtained from two to six villages for each group (Table 1). There were 187 reports of plants used to treat diabetes (Table 2). Surprisingly, over 70% of all use reports were from Rural Thai villages, despite this group representing less than half of the 44 villages studied. The 187 use reports were associated with 123 plant species in 104 genera and 52 families. *Tinospora crispa* (L.) Hook. f. & Thomson was the most commonly reported for treatment of diabetes (9 use reports). *Morinda citrifolia* L. and *Phyllanthus amarus* Schumach. & Thonn. Followed with six use reports each (Table 1). The family Leguminosae accounted for most use reports (16) followed by Lamiaceae with 14 use reports. Interestingly, the grass family, Poaceae, was in the third most common, with 13 use reports, despite not usually ranking highly among the families with ethnomedicinal uses. There were more than 10 reports of the use of each of Phyllanthaceae, Rubiaceae, and Acanthaceae (Figure 1). The remaining 35 families (pooled in Figure 1), had fewer than four use reports each and 22 families had only a single use report each (Table 1).

Regarding the parts of plants used to produce medicines for diabetes treatment, stems were the most commonly reported (40 use reports). Roots were mentioned as an ingredient in diabetes medicines in 38 reports. Approximately one third of all reports mentioned that either leaves (32 reports) or entire plants (29 reports) were used. Other plant parts, such as fruit, inflorescences, and seeds, each accounted for fewer than 15 use reports (Figure 2). Although more than half of all reports did not mention how to prepare the medicines to treat diabetes and how to apply them, almost all that did, reported the use of a decoction for oral ingestion. Few use reports suggested that plants should be crushed, pressed, or powdered. However, all preparations were delivered via the oral route. Only few use reports suggested that the plants should be used in an unprepared form; for instance, eaten as a fresh vegetable (Table 1).

Table 1 Thai ethnic groups and the numbers of villages in which they were studied and use reports for Thai traditional plant medicines used for the treatment of diabetes.

Ethnic group	# villages	# use reports	Average use report/village
Rural Thai	21	134	6.4
Karen	6	23	3.8
Hmong	6	12	2
Mien	3	5	1.7
Lua	2	4	2
Phuthai	1	3	3
Khmu	1	2	2
Akha	1	1	1
Leu	1	1	1
Sakai	1	1	1
Thaiyai	1	1	1
Total	44	187	

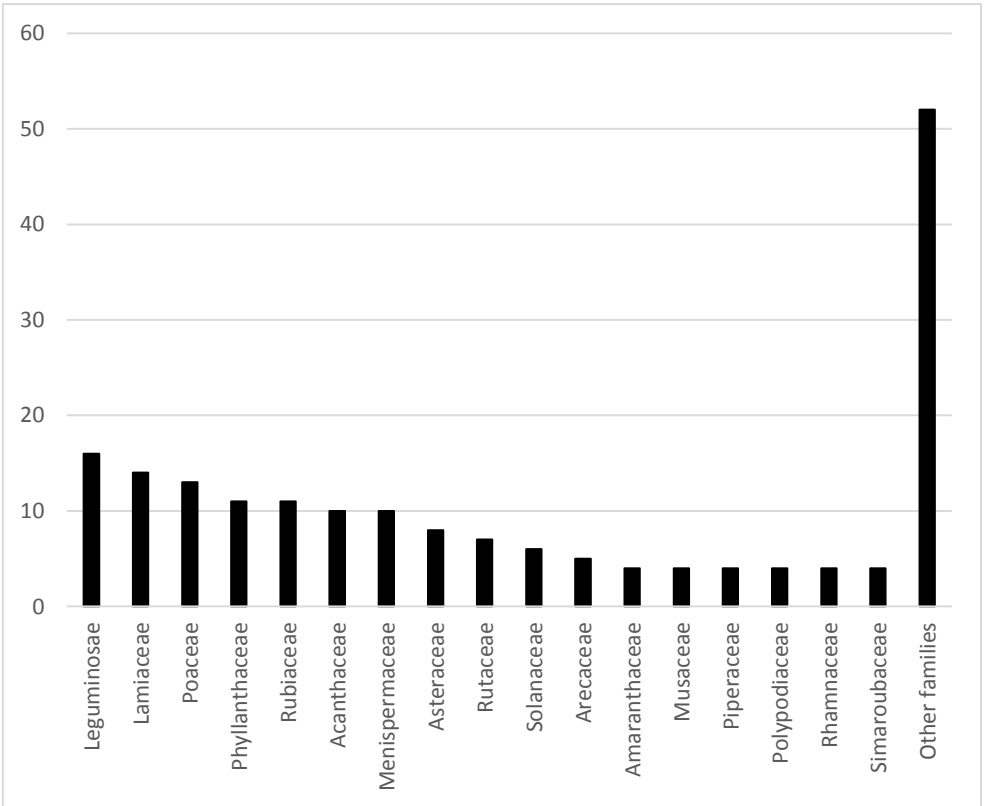

Figure 1 Number of use reports for diabetes treatment per plant family in Thailand (n = 187).

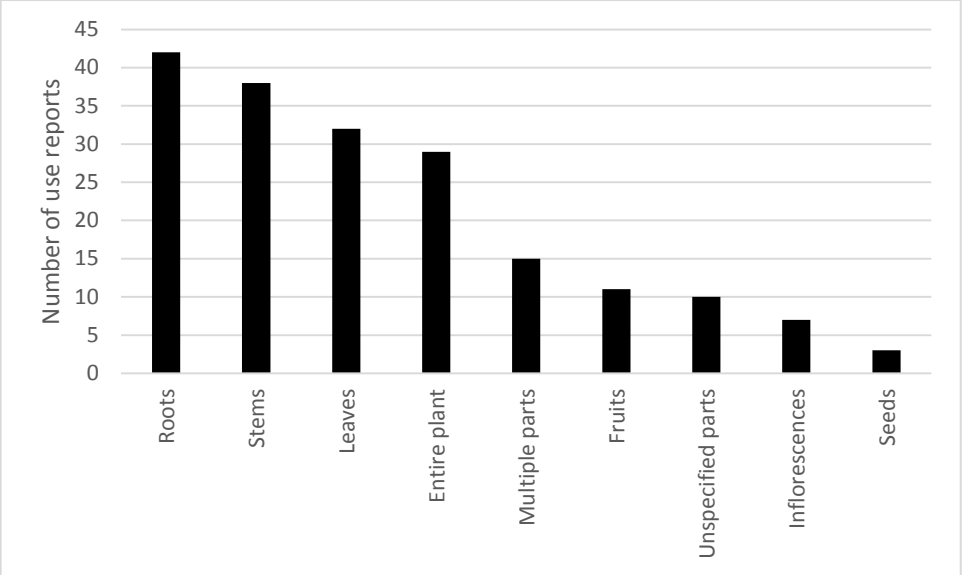

Figure 2 Number of use reports for various plant parts in diabetes treatment in Thailand (n = 187).

Table 2 Plant species, parts used, preparations, and routes of administration of diabetes treatment among 11 ethnic groups in 44 villages in Thailand. Rural Thai (B, M) indicates that the village populations comprised both Buddhists and Muslims.

Plant name	Used part	Preparation	Route of administration	Ethnic group	Reference
Acanthaceae					
Acanthus ebracteatus Vahl	Leaves			Rural Thai	[47]
Acanthus montanus (Nees) T. Anderson	Leaves	Decoction	Oral (liquid)	Karen	[37]
Andrographis paniculata (Burm. f.) Nees	Entire plant	Decoction	Oral (liquid)	Hmong	[41]
Andrographis paniculata (Burm. f.) Nees	Entire plant	Decoction	Oral (liquid)	Phuthai	[42]
Andrographis paniculata (Burm. f.) Nees	Leaves	Decoction	Oral (liquid)	Rural Thai	[34]
Clinacanthus nutans (Burm. f.) Lindau	Leaves	Decoction	Oral (liquid)	Rural Thai	[34]
Pseuderanthemum latifolium B. Hansen	Leaves			Hmong	[12]
Pseuderanthemum latifolium B. Hansen	Leaves			Khmu	[12]
Pseuderanthemum latifolium B. Hansen	Leaves			Mien	[12]

Thunbergia laurifolia Lindl.	Multiple	Decoction	Oral (liquid)	Rural Thai	[34]
Acoraceae					
Acorus calamus L.	Stem			Rural Thai	[43]
Amaranthaceae					
Aerva lanata (L.) Juss.	Entire plant			Rural Thai	[47]
Amaranthus blitum L.	Roots	Decoction	Oral (liquid)	Karen	[36]
Amaranthus spinosus L.	Roots	Decoction	Oral (liquid)	Karen	[36]
Gomphrena celosioides Mart.	Entire plant	Decoction	Oral (liquid)	Rural Thai	[44]
Annonaceae					
Annona reticulata L.	Leaves			Rural Thai	[47]
Ellipeiopsis ferruginea (Buch.–Ham. ex Hook. f. & Thomson) R. E. Fr.	Roots	Decoction	Oral (liquid)	Rural Thai	[18]
Apocynaceae					
Catharanthus roseus (L.) G. Don	Entire plant	Decoction	Oral (liquid)	Karen	[35]
Holarrhena pubescens Wall. ex G. Don	Multiple			Rural Thai	[44]
Plumeria rubra L.	Inflorescence	Decoction	Oral (liquid)	Rural Thai	[34]
Araliaceae					
Trevesia palmata (Roxb. ex Lindl.) Vis.	Fruit			Lua	[12]
Trevesia palmata (Roxb. ex Lindl.) Vis.	Stem			Mien	[12]
Arecaceae					
Areca catechu L.	Fruit	Decoction	Oral (liquid)	Rural Thai	[34]
Borassus flabellifer L.	Inflorescence	Decoction	Oral (liquid)	Leu	[33]
Eleiodoxa conferta (Griff.) Burret	Unspecified			Rural Thai	[47]
Metroxylon sagu Rottb.	Roots			Rural Thai	[47]
Nypa fruticans Wurmb	Unspecified parts			Rural Thai	[47]
Asparagaceae					
Asparagus racemosus	Entire plant	Decoction	Oral (liquid)	Karen	[35]

Willd.					
Asteraceae					
Chromolaena odorata (L.) R. M. King & H. Rob.	Leaves	Decoction	Oral (liquid)	Rural Thai	[33]
Cyanthillium cinereum (L.) H. Rob.	Roots	Decoction	Oral (liquid)	Rural Thai	[18, 19]
Cyanthillium cinereum (L.) H. Rob.	Multiple	Decoction	Oral (liquid)	Rural Thai	[34]
Eclipta prostrata (L.) L.	Entire plant			Rural Thai	[43]
Gynura nepalensis DC.	Leaves			Hmong	[12]
Gynura procumbens (Lour.) Merr.	Leaves			Khmu	[12]
Gynura procumbens (Lour.) Merr.	Leaves			Lua	[12]
Bignoniaceae					
Millingtonia hortensis L. f.	Stem	Powder	Oral (solid)	Rural Thai	[34]
Oroxylum indicum (L.) Kurz	Roots			Rural Thai	[47]
Celastraceae					
Salacia miqueliana Loes.	Roots			Rural Thai	[47]
Salacia miqueliana Loes.	Roots			Rural Thai	[47]
Chloranthaceae					
Chloranthus elatior Link	Roots	Decoction	Oral (liquid)	Karen	[36]
Combretaceae					
Terminalia calamansanay Rolfe	Stem			Rural Thai	[48]
Connaraceae					
Rourea asplenifolia (G. Schellenb.) Jongkind	Roots	Decoction	Oral (liquid)	Sakai	[39]
Convolvulaceae					
Ipomoea aquatica Forssk.	Entire plant			Rural Thai	[32]
Cucurbitaceae					
Coccinia grandis (L.) Voigt	Stem			Rural Thai	[18]
Coccinia grandis (L.)	Multiple			Rural Thai	[38]

Voigt					
Momordica charantia L.	Multiple	None	Eat as vegetable	Hmong	[50]
Cycadaceae					
Cycas micholitzii Dyer	Stem	Decoction	Oral (liquid)	Rural Thai	[34]
Dioscoreaceae					
Tacca chantrieri André	Stem			Hmong	[12]
Elaeocarpaceae					
Elaeocarpus tectorius (Lour.) Poir.	Stem			Rural Thai	[47]
Equisetaceae					
Hippochaete debilis (Roxb. ex Vaucher) Ching	Entire plant	Decoction	Oral (liquid)	Karen	[36]
Erythroxylaceae					
Erythroxylum cuneatum (Miq.) Kurz	Roots	Decoction	Oral (liquid)	Rural Thai	[18, 19]
Gentianaceae					
Fagraea ceilanica Thunb.	Roots	Decoction	Oral (liquid)	Rural Thai	[55]
Lamiaceae					
Clerodendrum infortunatum L.	Roots	Decoction	Oral (liquid)	Hmong	[40]
Orthosiphon aristatus (Blume) Miq.	Roots	Decoction	Oral (liquid)	Karen	[36]
Orthosiphon aristatus (Blume) Miq.	Stem	Decoction	Oral (liquid)	Phuthai	[42]
Orthosiphon aristatus (Blume) Miq.	Entire plant			Rural Thai (B, M)	[47]
Orthosiphon aristatus (Blume) Miq.	Leaves			Rural Thai	[12]
Plectranthus amboinicus (Lour.) Spreng.	Leaves	Decoction	Oral (liquid)	Karen	[35]
Premna herbacea Roxb.	Roots	Decoction	Oral (liquid)	Rural Thai	[18]
Premna herbacea Roxb.	Roots	Decoction	Oral (liquid)	Rural Thai	[19]
Tectona grandis L. f.	Roots	Decoction	Oral (liquid)	Rural Thai	[43, 46]
Tectona grandis L. f.	Multiple			Rural Thai	[44, 58]

Vitex glabrata R. Br.	Unspecified			Rural Thai	[57]
Leguminosae					
Abrus precatorius L.	Multiple	Decoction	Oral (liquid)	Rural Thai	[43]
Acacia concinna (Willd.) DC.	Entire plant			Rural Thai	[47]
Archidendron jiringa (Jack) I. C. Nielsen	Stem			Rural Thai (B, M)	[47]
Flemingia ferruginea Benth.	Roots	Decoction	Oral (liquid)	Karen	[36]
Leucaena leucocephala (Lam.) de Wit	Seeds			Rural Thai	[44]
Leucaena leucocephala (Lam.) de Wit	Unspecified			Rural Thai	[57]
Mimosa pudica L.	Multiple	Decoction	Oral (liquid)	Rural Thai	[43]
Mimosa pudica L.	Entire plant			Hmong	[12]
Parkia speciosa Hassk.	Roots			Rural Thai	[47]
Parkia speciosa Hassk.	Seeds			Rural Thai	[58]
Parkia timoriana (DC.) Merr.	Roots			Rural Thai	[47]
Psophocarpus tetragonolobus (L.) DC.	Stem			Rural Thai	[43]
Senna siamea (Lam.) H. S. Irwin & Barneby	Leaves	Decoction	Oral (liquid)	Rural Thai	[43]
Senna timoriensis (DC.) H. S. Irwin & Barneby	Multiple			Akha	[49]
Tamarindus indica L.	Leaves			Rural Thai	[47]
Loganiaceae					
Strychnos vanprukii Craib	Stem	Decoction	Oral (liquid)	Rural Thai	[55]
Loranthaceae					
Dendrophthoe pentandra (L.) Miq.	Entire plant	Decoction	Oral (liquid)	Rural Thai	[55]
Lythraceae					
Lagerstroemia speciosa (L.) Pers.	Leaves	Decoction	Oral (liquid)	Rural Thai	[43, 47]
Malvaceae					
Abutilon indicum (L.)	Multiple	Decoction	Oral (liquid)	Rural Thai	[43, 44]

Sweet					
Helicteres hirsuta Lour.	Roots	Decoction	Oral (liquid)	Rural Thai	[32]
Menispermaceae					
Arcangelisia flava (L.) Merr.	Multiple			Rural Thai	[45]
Tinospora crispa (L.) Hook. f. & Thomson	Stem	Decoction	Oral (liquid)	Karen	[36]
Tinospora crispa (L.) Hook. f. & Thomson	Stem	Decoction	Oral (liquid)	Rural Thai	[43, 59]
Tinospora crispa (L.) Hook. f. & Thomson	Stem			Hmong	[12]
Tinospora crispa (L.) Hook. f. & Thomson	Stem			Lua	[12]
Tinospora crispa (L.) Hook. f. & Thomson	Stem			Phuthai	[42]
Tinospora crispa (L.) Hook. f. & Thomson	Stem			Rural Thai	[44]
Tinospora crispa (L.) Hook. f. & Thomson	Stem			Mien	[12]
Moraceae					
Morus alba L.	Stem	Decoction	Oral (liquid)	Karen	[53]
Musaceae					
Ensete superbum (Roxb.) Cheesman	Inflorescence			Rural Thai	[43]
Musa acuminata Colla	Inflorescence			Rural Thai	[58]
Musa paradisiaca L.	Inflorescence	Decoction	Oral (liquid)	Karen	[54]
Musa paradisiaca L.	Stem			Rural Thai	[47]
Myrtaceae					
Syzygium cumini (L.) Skeels	Fruits			Rural Thai	[44, 58]
Oxalidaceae					
Averrhoa carambola L.	Leaves	Decoction	Oral (liquid)	Rural Thai	[43]
Biophytum sensitivum (L.) DC.	Entire plant			Rural Thai	[18, 44]
Pandanaceae					
Pandanus amaryllifolius Roxb.	Leaves	Decoction	Oral (liquid)	Karen	[36]

Passifloraceae					
Passiflora foetida L.	Roots			Rural Thai	[44]
Pentaphylacaceae					
Eurya acuminata DC.	Multiple	Decoction	Oral (liquid)	Hmong	[52]
Phyllanthaceae					
Phyllanthus amarus Schumach. & Thonn.	Entire plant	Decoction	Oral (liquid)	Karen	[36]
Phyllanthus amarus Schumach. & Thonn.	Entire plant	Decoction	Oral (liquid)	Rural Thai	[56]
Phyllanthus amarus Schumach. & Thonn.	Stem	Decoction	Oral (liquid)	Rural Thai	[34]
Phyllanthus amarus Schumach. & Thonn.	Entire plant			Rural Thai	[58, 47]
Phyllanthus collinsiae Craib	Stem	Decoction	Oral (liquid)	Rural Thai	[18, 56]
Phyllanthus emblica L.	Fruit	None	Oral (solid)	Rural Thai	[34]
Phyllanthus urinaria L.	Entire plant			Rural Thai	[47]
Sauropus kerrii Airy Shaw	Roots	Decoction	Oral (liquid)	Rural Thai	[55]
Piperaceae					
Piper nigrum L.	Fruit	Decoction	Oral (liquid)	Rural Thai	[34]
Piper retrofractum Vahl	Multiple	Decoction	Oral (liquid)	Rural Thai	[34]
Piper retrofractum Vahl	Fruit			Rural Thai	[47]
Piper sarmentosum Roxb.	Entire plant			Rural Thai	[47]
Plantaginaceae					
Scoparia dulcis L.	Entire plant			Mien	[12]
Poaceae					
Cymbopogon citratus (DC.) Stapf	Entire plant	Decoction	Oral (liquid)	Hmong	[51]
Cymbopogon citratus (DC.) Stapf	Unspecified	Decoction	Oral (liquid)	Karen	[36]
Dendrocalamus brandisii (Munro) Kurz	Leaves			Karen	[36]
Dendrocalamus hamiltonii Nees & Arn. ex Munro	Leaves			Karen	[36]

Dendrocalamus strictus (Roxb.) Nees	Leaves			Karen	[36]
Gigantochloa albociliata (Munro) Kurz	Leaves			Karen	[36]
Oryza sativa L.	Seeds	Decoction	Oral (liquid)	Rural Thai	[34]
Pogonatherum paniceum (Lam.) Hack.	Unspecified			Rural Thai	[57]
Saccharum officinarum L.	Stem	Decoction	Oral (liquid)	Rural Thai	[34]
Saccharum officinarum L.	Stem			Rural Thai	[47]
Saccharum spontaneum L.	Stem			Hmong	[51]
Thyrsostachys siamensis Gamble	Leaves			Karen	[36]
Vietnamosasa pusilla (A. Chev. & A. Camus) T. Q. Nguyen	Unspecified			Rural Thai	[57]
Polypodiaceae					
Drynaria quercifolia (L.) J. Sm.	Leaves	Decoction	Oral (liquid)	Karen	[53]
Drynaria quercifolia (L.) J. Sm.	Stem			Rural Thai	[43, 44, 48]
Rhamnaceae					
Ziziphus oenoplia (L.) Mill.	Multiple			Rural Thai	[18, 43, 44]
Ziziphus oenoplia (L.) Mill.	Roots			Rural Thai	[48]
Rubiaceae					
Catunaregam tomentosa (Blume ex DC.) Tirveng.	Unspecified			Rural Thai	[57]
Mitragyna speciosa (Korth.) Havil.	Leaves			Rural Thai	[47]
Morinda angustifolia Roxb.	Roots	Decoction	Oral (liquid)	Rural Thai	[43]
Morinda citrifolia L.	Fruits	Decoction	Oral (liquid)	Rural Thai	[34]
Morinda citrifolia L.	Fruit			Rural Thai	[32]
Morinda citrifolia L.	Roots			Rural Thai	[43, 44,

					48]
Morinda citrifolia L.	Unspecified			Rural Thai	[57]
Tamilnadia uliginosa (Retz.) Tirveng. & Sastre	Stem	Decoction	Oral (liquid)	Rural Thai	[18]
Tamilnadia uliginosa (Retz.) Tirveng. & Sastre	Stem	Decoction	Oral (liquid)	Rural Thai	[18]
Rutaceae					
Aegle marmelos (L.) *Correa*	Fruit	Decoction	Oral (liquid)	Rural Thai	[34]
Citrus aurantiifolia (Christm.) Swingle	Fruit	Juice with honey	Oral (liquid)	Rural Thai	[34]
Clausena excavata Burm. f.	Leaves	Crushed	Poultice	Rural Thai	[18, 19]
Clausena harmandiana (Pierre) Guillaumin	Roots	Decoction	Oral (liquid)	Rural Thai	[18, 19]
Naringi crenulata (Roxb.) Nicolson	Stem	Decoction	Oral (liquid)	Rural Thai	[55]
Salicaceae					
Flacourtia indica (Burm. f.) Merr.	Unspecified			Rural Thai	[57]
Simaroubaceae					
Brucea javanica (L.) Merr.	Multiple	Decoction	Oral (liquid)	Rural Thai	[18, 19]
Eurycoma longifolia Jack	Roots	Decoction	Oral (liquid)	Rural Thai	[34]
Eurycoma longifolia Jack	Roots	Powder	Oral (solid)	Rural Thai	[55]
Smilacaceae					
Smilax glabra Roxb.	Stem	Decoction	Oral (liquid)	Rural Thai	[18, 19]
Smilax ovalifolia Roxb. ex D.Don	Roots	Decoction	Oral (liquid)	Rural Thai	[34]
Solanaceae					
Physalis angulata L.	Roots			Rural Thai	[43, 48]
Solanum indicum L.	Inflorescence			Hmong	[12]
Solanum indicum L.	Entire plant			Rural Thai (B, M)	[47]
Solanum torvum Sw.	Multiple	Decoction	Oral (liquid)	Rural Thai	[34]
Stemonaceae					
Stemona tuberosa Lour.	Stem	Decoction	Oral (liquid)	Rural Thai	[34]

Urticaceae					
Elatostema longipes W. T.Wang	Leaves			Lua	[12]
Verbenaceae					
Stachytarpheta jamaicensis (L.) Vahl	Entire plant	Decoction	Oral (liquid)	Karen	[35]
Zingiberaceae					
Alpinia conchigera Griff.	Stem			Rural Thai	[18]

4. Discussion

Based on the results of our previous study of all traditional medicinal plants used in Thailand [10] and considering the prevalence of diabetes in Thailand (Ministry of Public Health, www.moph.go.th), it was surprising that less than half (n = 44) of all 121 villages originally studied, used plants for treating diabetes. More than 70% of all reports of traditional medicinal plant use for diabetes treatments were obtained from the Rural Thai population; this could be due to sample size bias. Almost half of all the village populations studied were categorized as Rural Thai, whereas the other half were represented by 10 different ethnic groups (Table 1). However, the proportion of use reports among Rural Thai individuals (72%) is higher than the proportion of Rural Thai villages studied (61%). This is possibly because Rural Thai people use plants to treat diabetes more frequently than the ethnic minority groups in Thailand because they have higher rates of diabetes than the minority ethnic groups. Unfortunately, this theory cannot be tested based on the reports from the Ministry of Public Health (www.moph.go.th), which presents diabetes rates only at the province scale. Alternatively, it can be speculated that the other ethnic minorities are not fully aware of the symptom of diabetes. The ethnic minority groups, especially the hill tribes, such as Karen, Hmong, and Mien, predominantly used medicines to treat basic symptoms such as fever, fresh wounds, infected wounds, and headache. Many of the symptoms related to hyperglycemia, such as increased thirst and urine volume, recurrent infections, weight loss, drowsiness, and coma [20], were treated in isolation rather than as the underlying disease, in this case, diabetes. Therefore, “diabetes” was not mentioned when these individuals from these ethnic minority groups were asked about the uses of medicinal plants. Moreover, these individuals live in remote areas, and therefore, with limited access to other villages or modern healthcare systems. These circumstances prevent development of knowledge about complex diseases, such as diabetes. In contrast, the Rural Thai populations are likely to be better informed about diabetes than the ethnic minority groups living in remote areas due to the existence of community public health centers established by the Ministry of Public Health. Consequently, Rural Thai individuals diagnosed with diabetes preferentially adopt the use of specific plants to their condition. Alternatively, it could also be that people living in remote areas are less prone to contract diabetes than people living closer to a city. Type 2 diabetes is associated with specific dietary and environmental conditions [1]. Due to their poverty, the diet of people living in remote areas consists mainly of vegetables collected from the forest or home gardens. On the other hand, inhabitants of regions closer to cities have abundant access to various food types, including

unhealthy food. This factor may the diabetes-related use reports and numbers of plant species used were higher among the Rural Thai villages than the ethnic minority groups.

Of 1,200 plant species cited worldwide for the treatment of diabetes [21], this study revealed that 123 species, or just over 10%, were used in Thailand alone. Furthermore, it is highly likely that there are more native Thai plants that are useful in traditional diabetes treatment, but were not captured in our data. Some of these, such as *Mammea siamensis* T. Anderson*, Mimusops elengi* L.*, Albizia myriophylla* Benth., *Terminalia chebula* Retz., *Kaempferia parviflora* Wall., and *Houttuynia cordata* Thunb., have documented antioxidant activity, which is effective in diabetes treatments and could be related to their use for this purpose in Thai folk medicine [22, 23].

The number of Thai plants listed here used in diabetes treatment is much higher than the numbers reported elsewhere when compared to other systems of traditional medicine, such as that of the ethnic minority Cree in Quebec, Canada (18 species) [24], Iran (82 species) [25], the western Anti-Atlas of Morocco (48 species) [26], the Lower Eastern Province of Kenya (39 species) [27], and the Maritime Region of Togo (65 species) [28].

The prevalence of reports of the use of Leguminosae was unsurprising. This family of plants is among the largest [11], and it also has the highest number of overall medicinal uses among the 206 families found in Thailand, ranking above Lamiaceae, Phyllanthaceae, Rubiaceae, and Acanthaceae [10]. These families and also Poaceae, are cited in diabetes treatments worldwide [21]. Interestingly, the grass family, Poaceae, is important for the treatment of diabetes in Thailand and worldwide, despite the relatively few ethnomedicinal uses of grasses around the world [13-19,29-33,62,63]. Grasses have fewer use reports in Thailand [10] relative to the proportion of species among the total flora in this region (Phumthum et al. *in prep.*). However, grasses are also medicinally important in Hawaii [64]. This controversial finding from investigations of the overall medicinal uses in Thailand combined the results from the Hawaiian pharmacopoeia suggest that plants from this family could be effective in diabetes treatments.

Tinospora crispa (L.) Hook. f. & Thomson was by far the most commonly reported species for treatments of diabetes in traditional Thai medicine. Apart from its use in diabetes treatments, it has been used as an anti-inflammatory based on its tinocriposide content [65], as a cardioprotective to treat hypertension [48] as well as an immunomodulatory, cytotoxic, and antimalarial herbal drug [66]. Results from several studies have confirmed that *T. crispa* is effective for diabetes treatment [67-69]. Preliminary studies have also indicated that *Morinda citrifolia* L. and *Phyllanthus amarus* Schumach. & Thonn. are effective for the treatment of this disorder [70-73]. Recent pharmacological trials of a related species, *Phyllanthus acidus* L., have not only shown reduced blood sugar levels in rats treated with extracts of this species, but also that these extracts were non-toxic in concentrations that had glucose lowering effects [74]. We propose that these plant species should be tested further for their potential as diabetes treatments for use in rural areas.

The selection of plant parts for medicinal use is greatly affected by availability. Patients with diabetes require medication throughout the year. Stems, roots, and leaves are abundant and can be harvested in any time of the year [79], whereas flowers, fruits, and seeds are seasonal. Stems, roots, and leaves were the most commonly used plant parts for diabetes treatment. Which is consistent with common worldwide patterns of medicinal plant use [75-79] including Thailand [10]. Seasonal plant parts such as flowers or fruits are more limited in their utility for medicinal purposes because treatment may be required out-of-season. In addition, flowers, fruits, and seeds

often contain high levels of sugar and starch that the plants use to attract pollinators and dispersers. However, these contents would counteract the diabetes treatment since high sugar or starch food will increase blood sugar levels. Therefore, seasonal plant parts may not be attractive for recipes for ethnobotanical diabetes treatments even if they contain high levels of compounds suitable for this purpose.

Decoction was the most common method for preparations and ingestion was the universal route of administration for all medicinal applications. This is commonly observed in the use of medicinal plants worldwide [26, 80-82]. Medicinal compounds are most easily extracted by boiling the plants. Local people may not have much knowledge concerning plant compound extractions. Although there are several specific methods for extracting compounds, such as alcohol extraction, distillation, and chromatography, local populations were aware only of decoction for obtaining medicinal compounds from plants. However, it can be speculated that the application of other technologies in combination with ethnobotanical knowledge would improve the yield of effective compounds from these plants.

Ingestion was the only route of application of the medicines for diabetes treatment, which is also consitent with common patterns [26, 83-84]. This is a rational method of application for this purpose, because diabetes is a condition arising with an inability to control blood sugar levels. Ingested medicines enter the digestive system and subsequently absorbed into to the circulatory system, which allows direct access to target cells for the control of glucose levels.

5. Conclusions

In our review of ethnobotanical medicine studies reported over past 25 years, we documented 187 use reports from 123 plant species used to treat diabetes in Thailand. These species were representatives of 52 plant families, the most common of which were Leguminosae, Lamiaceae, Poaceae, Phyllanthaceae, Rubiaceae, and Acanthaceae, whereas the most commonly reported species were *Tinospora crispa* (L.) Hook. f. & Thomson, *Morinda citrifolia* L. and *Phyllanthus amarus* Schumach. & Thonn. Comparison with pharmacological studies showed that some of these plants contain compounds that are effective in diabetes treatments. Our study represents a preliminary investigation, which eventually may lead to the identification of plant species that can be used as alternatives to expensive commercially available medicines for the treatment of diabetes. The potential species for diabetes treatment in rural populations warrant further investigation to identify their active compounds, as well as the distribution of these compounds in different parts of the plants and through the seasons. New, more efficient and precise extraction methods and strategies for the application of these treatments for diabetes in rural areas should also be developed. Finally, pre-clinical and clinical trials are needed to confirm the pharmacological value of these treatments for diabetes in rural populations.

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Author Contributions

MP and HB conceived the study; MP constructed the database and extracted the relevant data; MP and HB wrote the manuscript.

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Competing Interests

The authors declare that they have no competing interests.

Additional Materials

Appendix 1 List of 31 ethnobotanical references for traditional plant based diabetes treatments in Thailand.

1. Srithi K. Comparative ethnobotany in Nan province, Thailand. PhD thesis, Biology. Chiang Mai University Library, Chiang Mai. 2012.
2. Chuakul W, Saralamp P, Boonpleng A. Medicinal plants used in the Kutchum district, Yasothon province, Thailand. Thai J Phytopharm. 2002; 9.
3. Chuakul W, Saralamp P, Boonpleng A, Medicinal plants used in the Loengnoktha district, Yasothon province, Thailand. Thai J Phytopharm. 2002; 9.
4. Charnprasert C, Chanuwanit N. Exploration and collection of medicinal plants in wasted areas of Muang district, Nonthaburi province. Kasersart J (Nat Sci). 1992; 26: 19.
5. Inta, A., Ethnobotany and crop diversity of Tai Lue and Akha communities in the upper northern Thailand and the Xishuangbanna Dai automous prefecture, Chaina, PhD thesis in Biology. 2008; Chiang Mai University: Chiang Mai.
6. Inta A, Trisonthi P, Trisonthi C. Analysis of traditional knowledge in medicinal plants used by Yuan in Thailand. J Ethnopharmacol. 2013; 149: 344-351.
7. Junkhonkaen J. Ethnobotany of Ban Bowee, Amphoe Suan Phueng, Changwat Ratchaburi, Thesis in Economic Botany. 2012, Kasetsart University: Bangkok.
8. Kamwong K. Ethnobotany of Karens at Ban Mai Sawan and Ban Huay Pu Ling,Ban Luang Sub-District, Chom Thong District, Chiang Mai Province. Thesis in Biology. 2010, Chiang Mai University: Chiang Mai.
9. Trisonthi C, Trisonthi P. Ethnobotany of Karen at Mae Hae Nua, Mae Na Chorn, Mae Chaem District, Chaiang Mai Province (in Thai). 1995; Chulalongkorn Univerity, Bangkok.
10. Khuankaew S, Srithi K, Tiansawat P, Jampeetong A, Inta A, Wangpakapattanawong P. Ethnobotanical study of medicinal plants used by Tai Yai in Northern Thailand. J Ethnopharmacol. 2014; 151: 829-838.
11. Maneemoon K. Ethnobotany of Sakai Tribe in Trang, Phattalung and Yala Provinces, in Botany. 2001; Prince of Songkla University, Songkla.
12. Nuammee A. Ethnobotany of Hmong in Ban Pang Chang, Tambon Pong, Amphoe Santisuk, Changwat Nan, in Botany. 2012; Chulalongkorn University, Bangkok.
13. Pipitkul S. Medicinal plant utilization for the living of hill tribes at Doi Musoe, Tak province. Thesis in Technology of Environmental Management. 2001; Mahidol University, Bangkok.

14. Pannet P. Life belief and ritual relating to herbal utilization : a medical ethobotanic study in Phu Thai ethnic group at Don Mai Khum village Kalasin province Thailand. Thesis in Plant Science. 2008; Mahidol University, Bangkok.
15. Pantarod B. A Survey and Collection of Medicinal Plants at Na Kwang Village, Bo Kleau District, Nan Province. Thesis in Biology. 2002; Chiang Mai University: Chiang Mai.
16. Sinworn S., Viriyawattana, N. The diversity of medicinal plants and utilization in Khoa Phra, Doembangnangbuat District, Suphanburi Province. SDU Res J Sci Tech. 2014; 7: 19.
17. Osiri S. Traditional healers and medicinal plants in Chachoengsao Province (Thailand). J Thai Trad Alternat Med. 2011; 9.
18. Neamsuvan O, Komonhiran P, Boonming K, Medicinal plants used for hypertension treatment by folk healers in Songkhla province, Thailand. J Ethnopharmacol. 2018; 214: 58-70.
19. Upho U. Ethnobotany of Buddhist and Muslim Thais in Some Locations in the Lower Part of Southern Thailand, Thesis in Biology. 2005; Chiang Mai University: Chiang Mai.
20. Wayo Y. A study on herbal plants used for healing of Ban Wang Phai community, Wichian Buri district, Phetchabun province. Thesis in Education of Environment. 2012; Uttaradit Rajabhat University: Uttaradit.
21. Anderson E.F. Plants and People of the Golden Triangle Ethnobotany of the Hill Tribes of Northern Thailand. Portland: Timber Press, Inc. 1993; 279.
22. Krueasan D. Management, Conservation and Utilization of Plant Species by Hmong of Pah Poo Chom Village, Mae Taeng District, Chiang Mai Province. Thesis in Biology. 2000; Chiang Mai University: Chiang Mai.
23. Gunsuwan P. Processes of transferring local wisdom on management of medicinal herbs diversity for traditional healing of Hmong Community : A Case study of Khun Chang Khian Village, Chang Phueak Sub-district, Mueang Chiang Mai District. Thesis in Man and Environment Management. 2011; Chiang Mai University: Chiang Mai.
24. Tichachart C. Ethnobotany of Hmong hilltribe in Tambon Kheknoi, Amphur Khaokor, Changwat Phetchabun. Thesis in Economic Botany. 2004; Kasetsart University: Bangkok.
25. Sukkho T. A Survey of medicinal plants used by Karen people at Ban Chan and Chaem Luang Subdidtricts, Mae Chaem District, Chiang Mai Province. Thesis in Biology. 2008; Chiang Mai University: Chiang Mai.
26. Sonsupub B. Ethnobotany of karen community in Raipa village, Huaykhayeng subdistrict, Thongphahpume district, Kanchanaburi province. Thesis in Hoticulture. 2010; Kasetsart University: Bangkok.
27. Chuakul W, Saralamp P, Boonpleng A. Medicinal plants used in the Loennoktha district, Yasothon province, Thailand. Thai J Phytopharm. 2002; 9.
28. Muangyen N. Ethnobotany of Tai Lue and Tai Yuan in Samoeng District, Chiang Mai Province. Thesis in Biology. 2013; Chiang Mai University: Chiang Mai.
29. Jearanai J. A study of traditional Thai complementary therapies, traditional Thai midwifery, and herbal utilization of traditional healers: a case study of traditinal healers living in Num Pung Dam, Sakon Nakhon province. 2012; Suranaree University of Technology Intellectual Repository: Nakhon Ratchasima.
30. Purintavaragul C, Wongnawa M, Thaina P. Medicinal plants diversity in Kao-Pra village, Thumbol Kao-Pra, Amphoe Rattapoom, Songkhla Province. Thaksin J, 2012; 15: 9.

31. Maneenoon K, Khuniad C, Teanuan Y, Saedan N, Prom-In S, Rukleng N et al. Ethnomedicinal plants used by traditional healers in Phatthalung Province, Peninsular Thailand. J Ethnobiol Ethnomed, 2015; 11.

References

1. IDF. Diabetes Atlas. 8th ed, ed. E. edition. Online: International Diabetes Federation. 2017.
2. Daneman, D. Type 1 diabetes. Lancet. 2006; 367: 847-858.
3. Chatterjee, S., Khunti, K., Davies, M.J. Type 2 diabetes. Lancet. 2017; 389: 2239-2251.
4. ADS. Diagnosis and Classification of Diabetes Mellitus. Diabetes Care. 2005; 28: s37-s42.
5. WHO. Global report on diabetes. World Health Organization. 2016.
6. Brandle M, Zhou H, Smith BR, Marriott D, Burke R, Tabaei BP et al. The Direct Medical Cost of Type 2 Diabetes. Diabetes Care. 2003; 26: 2300-2304.
7. Tu Y. The discovery of artemisinin (qinghaosu) and gifts from Chinese medicine. Nat Med. 2011; 17: 1217.
8. Habeck M. Diabetes treatments get sweet help from nature. Nat Med. 2003; 9: 1228.
9. IWGIA. Who we are: Indigenous peoples in Asia. 2010; Chiang Mai: International Work Group for Indigenous Affairs (IWGIA).
10. Phumthum M, Srithi K, Inta A, Junsongduang A, Tangjitman K, Pongamornkul W et al. Ethnomedicinal plant diversity in Thailand. J Ethnopharmacol. 2018; 214: 90-98.
11. Pooma R, Suddee S. Tem Smitinand's Thai Plant Names, revised. 2014; The Office of the Forest Herbarium, Department of National Parks, Wildlife and Plant Conservation, Bangkok.
12. Srithi K. Comparative ethnobotany in Nan province, Thailand. PhD thesis, Biology. Chiang Mai University Library, Chiang Mai. 2012.
13. Srithi K, Balslev H, Wangpakapattanawong P, Srisanga P, Trisonthi C. Medicinal plant knowledge and its erosion among the Mien (Yao) in northern Thailand. J Ethnophamacol. 2009; 123: 335-342.
14. Srithi K, Trisonthi C, Wangpakapattanawong P, Srisanga P, Balslev H. Plant diversity in Hmong and Mien home gardens in northern Thailand. Econ Bot. 2012; 66: 192-206.
15. Srithi K, Trisonthi C, Wangpakapattanawong P, Balslev H. Medicinal plants used in Hmong women's healthcare in northern Thailand. J Ethnopharmacol. 2012; 139: 119-135.
16. Inta A, Panee SA, Pongamornkul W. Medicinal plants in Ban Hua Thung community forest, Chiang Dao Wildlife Sanctuary, Chang Dao district, Chiang Mai province. Thai J Bot. 2013; 4: 20.
17. Ponpim Y. Ethnobotany of the hill trives in Kaenoy's and Nongkheuw's Royal Project in Chiang Mai. Master thesis, Biology. Chiang Mai University Libraly, Chiang Mai. 1996.
18. Chuakul W, Saralamp P, Boonpleng A. Medicinal plants used in the Kutchum district, Yasothon province, Thailand. Thai J Phytopharm. 2002a; 9.
19. Chuakul W, Saralamp P, Boonpleng A, Medicinal plants used in the Loengnoktha district, Yasothon province, Thailand. Thai J Phytopharm. 2002b; 9.
20. Alberti KGMM, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of diabetes mellitus. Provisional report of a WHO Consultation. Diabet Med. 1998; 15: 539-553.

21. Marles RJ, Farnsworth NR. Antidiabetic plants and their active constituents. Phytomed. 1995; 137-189.
22. Steinrut L, Itharat A, Ruangnoo S. Free radical scavenging and lipid peroxidation of Thai medicinal plants used for diabetic treatment. J Med Assoc Thai. 2011; 94: S178-182.
23. Narongchai P, Niwatananun K, Narongchai S, Kusirisin W, Jaikang C. Inhibition of procarcinogen activating enzyme CYP1A2 activity and free radical formation by caffeic acid and its amide analogues. Drug Metab Lett. 2016; 10: 187-194.
24. Leduc C, Coonishish J, Haddad P, Cuerrier A. Plants used by the Cree Nation of Eeyou Istchee (Quebec, Canada) for the treatment of diabetes: A novel approach in quantitative ethnobotany. J Ethnopharmacol. 2006; 105: 55-63.
25. Rezaei A, Farzadfard A, Amirahmadi A, Alemi M, Khademi M. Diabetes mellitus and its management with medicinal plants: A perspective based on Iranian research. J Ethnopharmacol. 2015; 175, 567-616.
26. Barkaoui M, Katiri A, Boubaker H, Msanda F. Ethnobotanical survey of medicinal plants used in the traditional treatment of diabetes in Chtouka Ait Baha and Tiznit (Western Anti-Atlas), Morocco. J Ethnopharmacol. 2017; 198, 338-350.
27. Keter LK, Mutiso PC. Ethnobotanical studies of medicinal plants used by Traditional Health Practitioners in the management of diabetes in Lower Eastern Province, Kenya. J Ethnopharmacol. 2012; 139: 74-80.
28. Kpodar MS, Lawson-Evi P, Bakoma B, Eklu-Gadegbeku K, Agbonon A, Aklikokou K, Gbeassor M. Ethnopharmacological survey of plants used in the treatment of diabetes mellitus in south of Togo (Maritime Region). J Herb Med. 2015; 5: 147-152
29. Moerman DE. An analysis of the food plants and drug plants of native North America. J Ethnopharmacol. 1996; 52.
30. Bennett BC. and Husby, C.E. Patterns of medicinal plant use: An examination of the Ecuadorian Shuar medicinal flora using contingency table and binomial analyses. J Ethnopharmacol. 2008; 116: 422-430.
31. Weckerle CS, Cabras S, Castellanos ME, Leonti M. Quantitative methods in ethnobotany and ethnopharmacology: Considering the overall flora—Hypothesis testing for over- and underused plant families with the Bayesian approach. J Ethnopharmacol. 2011; 137: 837-843.
32. Bourbonnas-Spear N, Awad R, Maquin P, Cal V, Vindas PS, Poveda L et al. Plant use by the q'eqchi' maya of belize in ethnopsychiatry and neurological pathology. Econ Bot. 2005; 59: 326-336.
33. Leonti M, Sticher O, Heinrich M. Antiquity of medicinal plant usage in two Macro-Mayan ethnic groups (Mexico). J Ethnopharmacol. 2003; 88.
34. Charnprasert C, Chanuwanit N. Exploration and collection of medicinal plants in wasted areas of Muang district, Nonthaburi province. Kasersart J (Nat Sci). 1992; 26: 19.
35. Inta, A., Ethnobotany and crop diversity of Tai Lue and Akha communities in the upper northern Thailand and the Xishuangbanna Dai automous prefecture, Chaina, PhD thesis in Biology. 2008; Chiang Mai University: Chiang Mai.
36. Inta A, Trisonthi P, Trisonthi C. Analysis of traditional knowledge in medicinal plants used by Yuan in Thailand. J Ethnopharmacol. 2013; 149: 344-351.
37. Junkhonkaen J. Ethnobotany of Ban Bowee, Amphoe Suan Phueng, Changwat Ratchaburi, Thesis in Economic Botany. 2012, Kasetsart University: Bangkok.

38. Kamwong K. Ethnobotany of Karens at Ban Mai Sawan and Ban Huay Pu Ling,Ban Luang Sub-District, Chom Thong District, Chiang Mai Province. Thesis in Biology. 2010, Chiang Mai University: Chiang Mai.
39. Trisonthi C, Trisonthi P. Ethnobotany of Karen at Mae Hae Nua, Mae Na Chorn, Mae Chaem District, Chaiang Mai Province (in Thai). 1995; Chulalongkorn Univerity, Bangkok.
40. Khuankaew S, Srithi K, Tiansawat P, Jampeetong A, Inta A, Wangpakapattanawong P. Ethnobotanical study of medicinal plants used by Tai Yai in Northern Thailand. J Ethnopharmacol. 2014; 151: 829-838.
41. Maneemoon K. Ethnobotany of Sakai Tribe in Trang, Phattalung and Yala Provinces, in Botany. 2001; Prince of Songkla University, Songkla.
42. Nuammee A. Ethnobotany of Hmong in Ban Pang Chang, Tambon Pong, Amphoe Santisuk, Changwat Nan, in Botany. 2012; Chulalongkorn University, Bangkok.
43. Pipitkul S. Medicinal plant utilization for the living of hill tribes at Doi Musoe, Tak province. Thesis in Technology of Environmental Management. 2001; Mahidol University, Bangkok.
44. Pannet P. Life belief and ritual relating to herbal utilization : a medical ethobotanic study in Phu Thai ethnic group at Don Mai Khum village Kalasin province Thailand. Thesis in Plant Science. 2008; Mahidol University, Bangkok.
45. Pantarod B. A Survey and Collection of Medicinal Plants at Na Kwang Village, Bo Kleau District, Nan Province. Thesis in Biology. 2002; Chiang Mai University: Chiang Mai.
46. Sinworn S., Viriyawattana, N. The diversity of medicinal plants and utilization in Khoa Phra, Doembangnangbuat District, Suphanburi Province. SDU Res J Sci Tech. 2014; 7: 19.
47. Osiri S. Traditional healers and medicinal plants in Chachoengsao Province (Thailand). J Thai Trad Alternat Med. 2011; 9.
48. Neamsuvan O, Komonhiran P, Boonming K, Medicinal plants used for hypertension treatment by folk healers in Songkhla province, Thailand. J Ethnopharmacol. 2018; 214: 58-70.
49. Upho U. Ethnobotany of Buddhist and Muslim Thais in Some Locations in the Lower Part of Southern Thailand, Thesis in Biology. 2005; Chiang Mai University: Chiang Mai.
50. Wayo Y. A study on herbal plants used for healing of Ban Wang Phai community, Wichian Buri district, Phetchabun province. Thesis in Education of Environment. 2012; Uttaradit Rajabhat University: Uttaradit.
51. Anderson E. F. Plants and people of the Golden Triangle ethnobotany of the hill tribes of northern Thailand. Portland: Timber Press, Inc. 1993; 279.
52. Krueasan D. Management, Conservation and Utilization of Plant Species by Hmong of Pah Poo Chom Village, Mae Taeng District, Chiang Mai Province. Thesis in Biology. 2000; Chiang Mai University: Chiang Mai.
53. Gunsuwan P. Processes of transferring local wisdom on management of medicinal herbs diversity for traditional healing of Hmong Community : A Case study of Khun Chang Khian Village, Chang Phueak Sub-district, Mueang Chiang Mai District. Thesis in Man and Environment Management. 2011; Chiang Mai University: Chiang Mai.
54. Tichachart C. Ethnobotany of Hmong hilltribe in Tambon Kheknoi, Amphur Khaokor, Changwat Phetchabun. Thesis in Economic Botany. 2004; Kasetsart University: Bangkok.
55. Sukkho T. A Survey of medicinal plants used by Karen people at Ban Chan and Chaem Luang Subdidtricts, Mae Chaem District, Chiang Mai Province. Thesis in Biology. 2008; Chiang Mai University: Chiang Mai.

56. Sonsupub B. Ethnobotany of karen community in Raipa village, Huaykhayeng subdistrict, Thongphahpume district, Kanchanaburi province. Thesis in Hoticulture. 2010; Kasetsart University: Bangkok.
57. Chuakul W, Saralamp P, Boonpleng A. Medicinal plants used in the Loennoktha district, Yasothon province, Thailand. Thai J Phytopharm. 2002; 9.
58. Muangyen N. Ethnobotany of Tai Lue and Tai Yuan in Samoeng District, Chiang Mai Province. Thesis in Biology. 2013; Chiang Mai University: Chiang Mai.
59. Jearanai J. A study of traditional Thai complementary therapies, traditional Thai midwifery, and herbal utilization of traditional healers: a case study of traditinal healers living in Num Pung Dam, Sakon Nakhon province. 2012; Suranaree University of Technology Intellectual Repository: Nakhon Ratchasima.
60. Purintavaragul C, Wongnawa M, Thaina P. Medicinal plants diversity in Kao-Pra village, Thumbol Kao-Pra, Amphoe Rattapoom, Songkhla Province. Thaksin J, 2012; 15: 9.
61. Maneenoon K, Khuniad C, Teanuan Y, Saedan N, Prom-In S, Rukleng N et al. Ethnomedicinal plants used by traditional healers in Phatthalung Province, Peninsular Thailand. J Ethnobiol Ethnomed. 2015; 11.
62. Saslis-Lagoudakis CH, Williamson EM, Savolainen V, Hawkins A. Cross-cultural comparison of three medicinal floras and implications for bioprospecting strategies. J Ethnopharmacol. 2011; 135: 476-487.
63. Douwes E, Crouch NR, Edwards TJ, Mulholland DA. Regression analyses of southern African ethnomedicinal plants: informing the targeted selection of bioprospecting and pharmacological screening subjects. J Ethnopharmacol. 2008; 119: 356-364.
64. Ford J, Gaoue OG. Alkaloid-Poor Plant Families, Poaceae and Cyperaceae, Are Over-Utilized for Medicine in Hawaiian Pharmacopoeia. Econ Bot. 2017; 71: 123-132.
65. Adnan AZ, Taher M, Afriani T, Fauzana A, Roesma DI, Putra AE. Anti-inflammatory activity of tinocrisposide by inhibiting nitric oxide production in lipopolysaccharides-stimulated raw 264.7 cells. Asian J Pharm Clin Res. 2018; 11: 149-153.
66. Ahmad W, Jantan I, Bukhari SNA. *Tinospora crispa* (L.) Hook. f. & Thomson: A review of its ethnobotanical, phytochemical, and pharmacological aspects. Front Pharmacol. 2016; 7.
67. Abu MN, Hassan HF, Yusoff R, Ismail WIW. *Tinospora crispa* methanolic crude extract activates apoptotic pathway of insulin resistant-HepG2 cell lines by improving the insulin sensitivity. Malays Appl Biolo. 2017; 46: 133-140.
68. Noor H, Ashcroft SJH. Pharmacological characterisation of the antihyperglycaemic properties of *Tinospora crispa* extract. J Ethnopharmacol. 1998; 62: 7-13.
69. Lam SH, Ruan CT, Hsieh PH, Su MJ, Lee SS. Hypoglycemic diterpenoids from *Tinospora crispa*. J Nat Prod. 2012; 75: 153-159.
70. Nayak BS, Marshall JR, Isitor G, Adogwa A. Hypoglycemic and hepatoprotective activity of fermented fruit juice of *Morinda citrifolia* (Noni) in diabetic rats. Evid Based Complementary Alternat Med. 2011.
71. Jensen CJ, Palu AK, Ohishi H, Tani H. Preventative and treatment effects of *Morinda citrifolia* on diabetes and its related conditions. 2005, Google Patents.
72. Raphael KR, Sabu M, Kuttan R. Hypoglycemic effect of methanol extract of *Phyllanthus amarus* Schum & Thonn on alloxan induced diabetes mellitus in rats and its relation with antioxidant potential. Indian J Exp Biol. 2002; 40: 905-909.

73. Shetti A, Sanakal R, Kaliwal B. Antidiabetic effect of ethanolic leaf extract of *Phyllanthus amarus* in alloxan induced diabetic mice. Asian J Plant Sci Res. 2012; 2: 11-15.
74. Chaimum-aom, N, Chomko S, Talubmook C. Toxicology and Oral glucose Tolerance Test (OGTT) of Thai medicinal plant used for diabetes controls, *Phyllantus acidus* L.(EUPHORBIACEAE). Pharmacog J. 2017; 9.
75. Asowata-Ayodele AM, Afolayan AJ, Otunola, GA. Ethnobotanical survey of culinary herbs and spices used in the traditional medicinal system of Nkonkobe Municipality, Eastern Cape, South Africa. South Afr J Bot. 2016; 104: 69-75.
76. Fortini P, Di Marzio P, Guarrera PM, Iorizzi M. Ethnobotanical study on the medicinal plants in the Mainarde Mountains (central-southern Apennine, Italy). J Ethnopharmacol. 2016; 184: 208-218.
77. Mukungu N, Abuga K, Okalebo F, Ingwela R, Mwangi J. Medicinal plants used for management of malaria among the Luhya community of Kakamega East sub- County, Kenya. J Ethnopharmacol. 2016; 194: 98-107.
78. Ouelbani R, Bensari S, Mouas TN, Khelifi D. Ethnobotanical investigations on plants used in folk medicine in the regions of Constantine and Mila (North-East of Algeria). J Ethnopharmacol. 2016; 194: 196-218.
79. Yemele MD, Telefo PB, Lienou LL, Tagne SR, Fodouop, CSP, Goka CS, Lemfack MC, Moundipa FP. Ethnobotanical survey of medicinal plants used for pregnant women ′s health conditions in Menoua division-West Cameroon. J Ethnopharmacol. 2015; 160: 14-31.
80. Afolayan AJ, Grierson DS, Mbeng WO. Ethnobotanical survey of medicinal plants used in the management of skin disorders among the Xhosa communities of the Amathole District, Eastern Cape, South Africa. J Ethnopharmacol. 2014; 153: 220-232.
81. Bahmani M, Zargaran A, Rafieian-Kopaei M, Saki K. Ethnobotanical study of medicinal plants used in the management of diabetes mellitus in the Urmia, Northwest Iran. Asian Pac J Trop Dis. 2014; 7: S348-S354.
82. Nowbandegani AS, Kiumarcy S, Rahmani F, Dokouhaki M, Khademian S, Zarshenas MM, Faridi P. Ethnopharmacological knowledge of Shiraz and Fasa in Fars region of Iran for diabetes mellitus. J Ethnopharmacol. 2015; 172: 281-287.
83. Benarba B, Belabid L, Righi K, amine Bekkar A, Elouissi M, Khaldi A, Hamimed A. Ethnobotanical study of medicinal plants used by traditional healers in Mascara (North West of Algeria). J Ethnopharmacol. 2015; 175: 626-637.
84. Semenya S, Potgieter M, Erasmus L. Ethnobotanical survey of medicinal plants used by Bapedi healers to treat diabetes mellitus in the Limpopo Province, South Africa. J Ethnopharmacol. 2012; 141: 440-445.

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