TRADITIONAL THAI YUAN MEDICINAL PLANTS FOR MUSCULOSKELETAL DISORDERS: A COMPREHENSIVE REVIEW

Rapeeporn Kantasrila*, and Prateep Panyadee

Queen Sirikit Botanic Garden, The Botanical Garden Organization, Mae Rim, Chiang Mai

*corresponding author e-mail: Rapeeporn.k19@gmail.com

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Abstract

Medicinal plants play an important role in healthcare systems worldwide, often serving as the primary treatment option for numerous ailments, including musculoskeletal system disorders (MSDs). With the global prevalence of MSDs on the rise, they contribute to an increased risk of other non-communicable diseases. This review aims to consolidate existing knowledge on medicinal plants used by Thai Yuan people in Thailand for treating MSDs and identify the most significant species using ethnobotanical indices. Data were collected from 13 studies conducted between 2001 and 2018, with the analysis focusing on Use Values (UV) and Informant Consensus Factor (ICF). A total of 138 species were identified from 311 use reports, with Acanthaceae emerging as the most dominant family. Leaves and stems constituted the most commonly utilized plant parts for medicinal purpose. Decoction and oral administration were the predominant preparation and routes of administration, respectively. *Plantago major*, *Crinum asiaticum* and *Elephantopus scaber* emerged as the most important species.

Keywords: Thai Yuan, Musculoskeletal pain, Lanna medicinal plants, Ethnobotany

INTRODUCTION

Plants have long played an important role in human life, particularly as sources of medicine (Inta, Trisonthi & Trisonthi, 2013; Phumthum et al., 2020; Prabhu et al., 2021). Many ethnic groups around the world use plants for food, clothing, medicine, and housing from birth through death (Inta, Trisonthi & Trisonthi, 2013; Prabhu et al., 2021). In many

impoverished and developing countries, medicinal plants are vital components of healthcare systems (Ong et al., 2018). Although modern medicine has been developed by scientific knowledge and cutting–edge technologies, people in many regions of the world consider medicinal plants for the first choice to treat many diseases (Phumthum et al., 2020; WHO, 2022). Countries such as China and India (Parrotta, 2002; Ved & Goraya, 2007) have a rich history of utilizing wild medicinal plants for use both locally and for export (Bodeker & Burford, 2005). Therefore, the study and conservation of medicinal plants is essential for rural communities and the pharmaceutical industry (Prabhu et al., 2021). Moreover, the study of medicinal plants helps to maintain and pass on valuable knowledge to future generations (Prabhu et al., 2021).

Thailand is a highly biodiverse country, with forests covering approximately 31.59 percent of its total areas (RFD, 2022). Over 10,000 plant species have been identified (Pooma, 2014), and the country's numerous ethnic groups rely heavily on these plants for various purposes, especially medicine (Kantasrila et al., 2017; Khuankaew et al., 2014; Phumthum et al., 2020; Srithi, 2012). More than 2000 species are used to treat a diverse range of diseases, including digestive system disorders, infections/infestations, nutritional disorders, musculoskeletal system disorders (Phumthum et al., 2018). Musculoskeletal system disorders (MSDs) encompass a variety of conditions affecting the movement system including muscles, bones, joints, and adjacent connective tissues (WHO, 2022). Approximately 1.71 million people worldwide suffer from MSDs, especially low back pain (Cieza et al., 2020). These conditions are prevalent due to population growth, aging (Cieza et al., 2020), and hard work (Holmberg et al., 2002). MSDs limit productivity, physical activity, and societal participation, while also increasing the risk of noncommunicable diseases such as cardiovascular disease and mental health problems (WHO, 2022). Medicinal plants have proven useful in treating musculoskeletal pain and disorders in various countries, including China (Arnold & Thornbrough, 1999), Thailand (Kantasrila et al., 2020), and Pakistan (Malik et al., 2018). Phytochemical compounds in many plants are reported to possess anti–inflammatory and analgesic properties, which can alleviate MSD symptoms (Kantasrila, 2021). Medicinal plants and herbal medicines are extensively utilized as both complementary and traditional therapies in the treatment of MSD (Arnold

& Thornbrough, 1999). Historically, China has employed herbal medicine in addressing MSD for several millennia (Arnold & Thornbrough, 1999). Concurrently, In Thailand, over 600 species of medicinal plants have been documented as effective remedies for this condition (Phumthum et al., 2018). Similarly, a multitude of plants species have long been recognized for their essential role in traditional treatments for musculoskeletal ailments (Cavero & Calvo, 2015). The global adoption of herbal medicines can be attributed to their safety, effectiveness, affordability, and accessibility (Rathi& Rathi, 2020). Consequently, the significance of medicinal plants in the management and treatment of MSD cannot be overstated.

The Thai Yuan, also known as Lanna people or Khon Muang inhabited several Asian countries including China, Laos, Myanmar, and the Northern of Thailand (Inta, Trisonthi & Trisonthi, 2013; Manosroi et al., 2015). They are the majority group of the northern Thailand (Panyadee et al., 2019) and primarily rely on agriculture for their livelihood. Rice are the most crucial crops for their live (Inta, Trisonthi & Trisonthi, 2013). Due to limited access to agricultural machinery, they depend on manual labor, leading to several health problems associated with muscular pain (Luangwilai, Norkaew & Siriwong, 2014; Sombatsawat et al., 2019). The Thai Yuan collect plants from the forests for many objectives, in particular food and medicine. The knowledges of Thai Yuan or Lanna medicinal plants have been recorded and used for over 700 years (Manosroi et al., 2015). The Thai Yuan have over 200,000 medicinal plant remedies (Manosroi et al., 2012).

However, studies focusing on the traditional medicine for treating MSD are scarce. This study aims to answer the following questions: 1) How many medicinal plants are used for treating MSD among Thai Yuan people? 2) What species are the most important for treating MSD based on ethnobotanical indices? and 3) Which MSDs are the most prevalence among Thai Yuan people?

METHODOLOGY

1. Ethnobotanical data

A systematic review of medicinal plants used to treat MSDs in Thai Yuan was conducted. The data were selected from different published research and unpublished

research such as journal publication, research articles, and proceedings. We also enriched our research by compiling the data from the Thai Library Integrated System's online theses database (www.tdc.thailis.or.th). Unpublished data were additionally sourced from the Ethnobotany and Northern Thai Flora Laboratory within Department of Biology, Chiang Mai University. To ensure comprehensive coverage, we also incorporated data from published journal articles, accessed via Scopus, Google Scholar, and Thai–Journal Citation Index.

During the search, terms such as "medicinal plants in Thai Yuan", "medicinal plants in Khon Muang", "Lanna plants", "medicinal plants to treat MSDs", "ethnobotany", *etc*. were used. To avoid duplication of data, we combined the data from different sources and selected only the data from theses if they had also been published in a journal. After that, the references of medicinal plants used to treat MSDs were selected based on such criteria as: the articles were published only between 2000 and 2020 and the data from references had to include the plant species, family, plant part used, and ailments of MSDs. In total, we obtained data from 13 references that provided information about the use of medicinal plant species to treat MSDs in the Thai Yuan community in Thailand.

2. Data Organization

We validated the scientific names and family names of medicinal plants mentioned in the ethnobotanical references using Plants of the World Online database (powo.science.kew.org/). The plant use reports from original research were classified to MSD categories following the International Classification of Primary Care, second edition (ICPC–2), which based on body system (WICC, 2005). Additionally, the use reports of medicinal plants were classified into groups based on plants part used, mode of preparation and mode of administration.

3. Data analysis

Important Medicinal plant

To identify the important medicinal plant species for treating MSDs, we used the Use Values (UV) calculation modified from Reyes–García et al. (2006) by following equation 1.

$$UV = \sum U_i / N \quad (1)$$

where U_i is the number of use reports for a particular species cited by each informant and N is the total number of informants. In this study, a "use report" refers to the use of a species for a specific ailment in each MSD category following ICPC–2. Additionally, we used each source of reference as a "pseudoinformant" to replace an individual person "informant" in the analysis (in this study, N=13). High UV indicate that the plant is very important for treating MSDs while UV approaching zero indicate that a plant has low number of use reports, and a plant has not importance to treat MSD.

Important MSD category

To determine the prevalence of MSD categories, we used the Informant Consensus Factor; ICF (Carocho & Ferreira, 2013). This index ranks the level of agreement among informants for medicinal plants used in each category (Trotter, 1986). The ICF was calculated using the following equation 2.

$$ICF = N_{ur} – N_t / N_{ur} – 1 \quad (2)$$

This index estimates the relationship between use reports in each category (Nur) and number of taxa used (Nt) (Canales et al., 2005). The value of this index ranges from 0 to 1. When ICF is near 0, it indicates that each informants chose different plants for a particular category. On the other hand, a high ICF value implies that a few species are used by a large proportion of informants, indicating agreement on the taxa to be used for treating a particular of ailment.

RESULT

1. Diversity of medicinal plants

Our review of the literature on medicinal plants used to treat MSD among Thai Yuan people identified 138 species belonging to 53 families and 110 genera. Of these plants, 48 species were part of medicinal plants recipes. A total of 311 use reports were recognized from 13 references. Among the recorded species, the dominant family was Acanthaceae, with 19 species. Other important families included Phyllanthaceae (12 species), Asteraceae (11 species), Fabaceae (11 species) and Zingiberaceae (10 species), respectively as Figure 1.

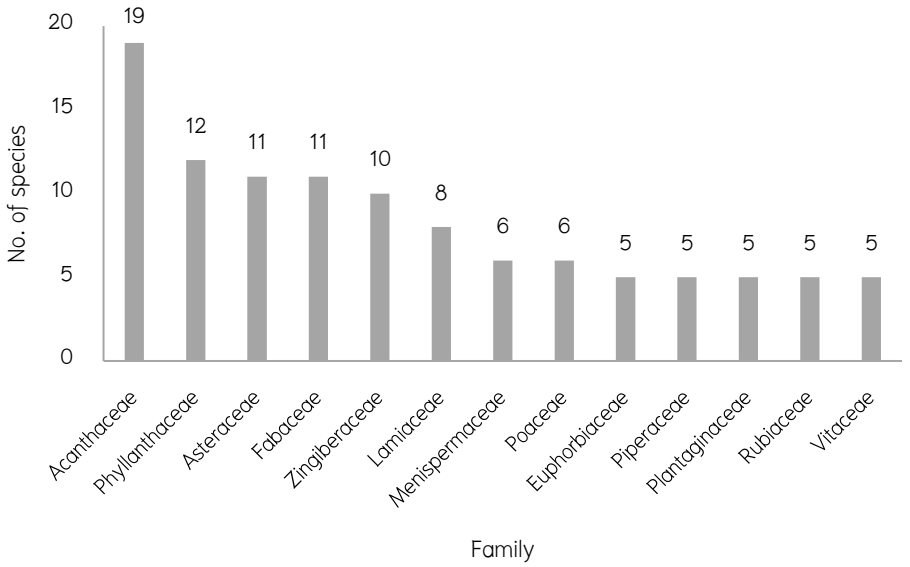

Figure 1 Thirteen plant families with the highest number of medicinal plant species to treat MSD of the Thai Yuan in Thailand.

2. Plant part used, preparation and routes of administration

The most commonly used plant parts to treat MSDs were leaves (29%) followed by stems (28%), roots (15%) and whole plants (11%) as Figure 2. Decoction was the most common methods of preparation, accounting for 43% of the total methods used. Other methods such as concoction, burning, and grinding were also popular for preparing some species to treat MSD. While many use reports did not describe the routes of administration, the most common way of administering them was through oral ingestion (48%).

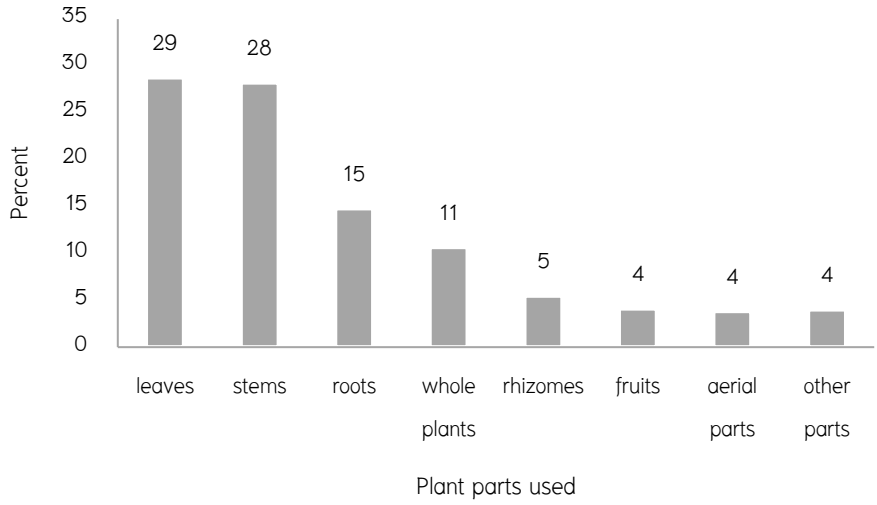

Figure 2 Parts of medicinal plants used to treat MSD of Thai Yuan in Thailand.

3. Important medicinal plant species and Important MSD category

Out of 138 species, *Plantago major* L. had the highest use reports (20 use reports) and UV values (1.54). It was reported to treat muscle pain, fracture, sprain, joint pain, knee pain and tendinitis from 7 references. *Crinum asiaticum* L. ranked second in terms of UV (0.92) and was used to treat muscle pain, sprain, knee pain and fracture from 4 references. *Elephantopus scaber* L. was the third most important species (UV=0.69) and was used to treat muscle pain, back pain, and flank pain from 6 references. Other species with high UV included *Alpinia galanga* (L.) Willd., *Blumea balsamifera* (L.) DC., *Phlogacanthus curviflorus* (Nees) Nees, *Rhinacanthus nasutus* (L.) Kurz and *Thunbergia laurifolia* Lindl. had high UV values. These species were recorded to be used for many MSD diseases as Table 1. The 311 use reports were classified to 17 MSD categories following ICPC–2, as Table 2. The informant consensus factor of MSD medicinal plants ranged from 0.00–0.75. The category with the highest ICF value was sprain/strain of joint (0.75), followed by muscle pain (0.37), bursitis/tendinitis/synovitis NOS (0.20), and fracture: other (0.20). The category with the highest use reports and number of species was muscle pain. However, four categories had only one–use reports, including chest symptom/complaint, fracture: radius/ulna, hand/finger symptom/complaint and osteoporosis categories.

Table 1 The top 20 most important medicinal plants, which had highest UV for treating MSD among Thai Yuan in Thailand.

Scientific name	Family	UV	Plant parts use	Preparation	Application	MSD categories	Reference
Plantago major L.	Plantaginaceae	1.54	aerial part, leaves, stem, whole plants	burning, grind, decoction, water infusion, concoction, crush, grind and burning, grind and decoction, grind, and water soak	compress, oral ingestion, poultices, soak	Bursitis/tendinitis/synovitis NOS, Dislocation/subluxation, Fracture: other, Hand/finger symptom/complaint, Joint symptom/complaint NOS, Knee symptom/complaint, Muscle pain, Osteoarthrosis other, Sprain/strain of joint NOS	(Inta, 2011; Inta, Trisonthi & Trisonthi, 2013; Pantarod, 2002; Panyadee, 2017; Sumridpiem, 2017; Trisonthi et al., 2007; Varipo, 2012)
Crinum asiaticum L.	Amaryllidaceae	0.92	leaves	burning, decoction	compress, poultices, soak	Fracture: other, Fracture: radius/ulna, Knee symptom/complaint, Muscle pain, Sprain/strain of joint NOS	(Inta, 2011; Inta, Trisonthi & Trisonthi, 2013; Songsangchun, 2015; Sumridpiem, 2017)
Elephantopus scaber L.	Asteraceae	0.69	leaves, root, stem, whole plants	alcoholic infusion, concoction, decoction, dried and concoction	oral ingestion	Back symptom/complaint, Flank/axilla symptom/complaint, Muscle pain	(Inta, 2011; Inta, Trisonthi & Trisonthi, 2013; Panyadee, 2010; Suthakul, 2002; Tovaranonte, 2001; Trisonthi et al., 2007)
Alpinia galanga (L.) Willd.	Zingiberaceae	0.46	rhizome, stem	burning and grind, concoction, decoction, none, dried	compress, soak	Joint symptom/complaint NOS, Knee symptom/complaint, Muscle pain	(Inta, 2018; Songsangchun, 2015; Sumridpiem, 2017)

Table 1 (Continued)

Scientific name	Family	UV	Plant parts use	Preparation	Application	MSD categories	Reference
Blumea balsamifera (L.) DC.	Asteraceae	0.46	leaves	burning, grind and hot water infusion	compress, oral ingestion	Back symptom/complaint, Joint symptom/complaint NOS, Muscle pain, Neck symptom/complain, Shoulder symptom/complaint	(Pantarod, 2002; Songsangchun, 2015; Sumridpiem, 2017)
Phlogacanthus curviflorus (Nees) Nees	Acanthaceae	0.46	leaves	burning and grind	compress, eaten as food	Back symptom/complaint, Leg/thigh symptom/complaint, Muscle pain, Neck symptom/complain, Shoulder symptom/complaint	(Songsangchun, 2015; Sumridpiem, 2017; Trisonthi et al., 2007)
Rhinacanthus nasutus (L.) Kurz	Acanthaceae	0.46	aerial part, leaves, root, stem, whole plants	decoction, dried	compress, oral ingestion	Back symptom/complaint, Flank/axilla symptom/complaint, Muscle pain	(Sumridpiem, 2017; Tovaranonte, 2001; Varipo, 2012)
Thunbergia laurifolia Lindl.	Acanthaceae	0.46	leaves, stem, whole plants	concoction, decoction	oral ingestion	Back symptom/complaint, Flank/axilla symptom/complaint, Knee symptom/complaint, Muscle pain	(Inta, 2011; Inta, Trisonthi & Trisonthi, 2013)
Catunaregam spathulifolia Tirveng.	Rubiaceae	0.38	stem	decoction	oral ingestion	Bursitis/tendinitis/synovitis NOS, Fracture: other, Knee symptom/complaint, Muscle pain, Sprain/strain of joint NOS	(Inta, 2011; Inta, Trisonthi & Trisonthi, 2013)
Croton persimilis Müll.Arg.	Euphorbiaceae	0.38	stem	concoction, decoction, none	oral ingestion	Back symptom/complaint, Flank/axilla symptom/complaint, Muscle pain	(Inta, 2011; Inta, Trisonthi & Trisonthi, 2013; Sumridpiem, 2017)

Table 1 (Continued)

Scientific name	Family	UV	Plant parts use	Preparation	Application	MSD categories	Reference
Phyllanthus amarus Schumach. & Thonn.	Phyllanthaceae	0.38	leaves, stem, whole plants	concoction, decoction	oral ingestion	Joint symptom/complaint NOS, Muscle pain, Osteoarthrosis other	(Inta, 2011; Inta, Trisonthi & Trisonthi, 2013; Sumridpiem, 2017; Trisonthi et al., 2007)
Phyllanthus emblica L.	Phyllanthaceae	0.38	bark, fruit, root, stem	concoction, decoction, none, pickled, pounding	eaten as food, oral ingestion	Back symptom/complaint, Flank/axilla symptom/complaint, Muscle pain	(Inta, 2011; Inta, Trisonthi & Trisonthi, 2013; Pantarod, 2002)
Tamarindus indica L.	Fabaceae	0.38	leaves, stem	burning, decoction, none, dried	compress, soak, steaming	Back symptom/complaint, Flank/axilla symptom/complaint, Muscle pain	(Pantarod, 2002; Sumridpiem, 2017)
Andrographis paniculata (Burm.f.) Wall. ex Nees	Acanthaceae	0.31	aerial part, whole plants	concoction, decoction, pounding, pill	oral ingestion	Back symptom/complaint, Flank/axilla symptom/complaint, Muscle pain	(Inta, 2011; Inta, Trisonthi & Trisonthi, 2013)
Mimosa pudica L.	Fabaceae	0.31	leaves, root, whole plants	burning, concoction, decoction	compress, oral ingestion	Knee symptom/complaint, Muscle pain	(Inta et al, 2018; Sumridpiem, 2017)
Tacca chantrieri André	Dioscoreaceae	0.31	leaves, rhizome, root	concoction, decoction	oral ingestion	Back symptom/complaint, Flank/axilla symptom/complaint, Muscle pain	(Songsangchun, 2015; Trisonthi et al., 2007; Varipo, 2012)
Tiliacora triandra (Colebr.) Diels	Menispermaceae	0.31	leaves, root	concoction, grind	eaten as food, oral ingestion	Joint symptom/complaint NOS, Knee symptom/complaint, Osteoarthrosis other	(Pantarod, 2002; Sumridpiem, 2017)
Acanthus montanus (Nees) T.Anderson	Acanthaceae	0.23	leaves	burning, hot water infusion, decoction	compress, oral ingestion	Bursitis/tendinitis/synovitis NOS, Muscle pain	(Sumridpiem, 2017)

Table 1 (Continued)

Scientific name	Family	UV	Plant parts use	Preparation	Application	MSD categories	Reference
Angelica dahurica (Hoffm.) Benth. & Hook.f. ex Franch. & Sav.	Apiaceae	0.23	rhizome	cook	eaten as food	Back symptom/complaint, Neck symptom/complain, Shoulder symptom/complaint	(Sumridpiem, 2017)
Averrhoa carambola L.	Oxalidaceae	0.23	fruit, leaves, root, stem	crush, none, decoction	oral ingestion	Back symptom/complaint, Flank/axilla symptom/complaint, Muscle pain	(Inta, 2011; Inta, Trisonthi & Trisonthi, 2013)

Table 2 Informant Consensus Factor (ICF) of MSD medicinal plants among Thai Yuan in Thailand.

Code	Category of MSD (ICPC–2)	Number of Use Reports (N_{ur})	Number of Species (N_t)	ICF
L79	Sprain/strain of joint NOS	9	3	0.75
L18	Muscle pain	140	88	0.37
L87	Bursitis/tendinitis/synovitis NOS	6	5	0.20
L76	Fracture: other	6	5	0.20
L15	Knee symptom/complaint	18	16	0.12
L05	Flank/axilla symptom/complaint	42	38	0.10
L02	Back symptom/complaint	40	37	0.08
L04	Chest symptom/complaint	1	1	0.00
L80	Dislocation/subluxation	2	2	0.00
L72	Fracture: radius/ulna	1	1	0.00
L12	Hand/finger symptom/complaint	1	1	0.00
L20	Joint symptom/complaint NOS	16	16	0.00
L14	Leg/thigh symptom/complaint	4	4	0.00
L01	Neck symptom/complain	6	6	0.00
L91	Osteoarthrosis other	12	12	0.00
L95	Osteoporosis	1	1	0.00
L08	Shoulder symptom/complaint	6	6	0.00

ICPC–2 = the International Classification of Primary Care, second edition

DISCUSSION

1. Diversity of medicinal plants and uses

The total number of species used to treat MSDs among Thai Yuan people accounts for 20 % of all medicinal plant diversity used for this purpose in Thailand (Phumthum et al., 2018). However, about 44% of the total plants used have only one–use report. This showed that Thai Yuan in different areas used different plants species to treat MSDs. The high number species, which have only one–use report need to urgent additively study before knowledge of these plants is disappear in the future (Panyadee et al., 2023). A significant portion, one third of these species, were medicinal plants recipe. Lanna or Thai Yuan recipes have been traditionally utilized for a considerable length of time (Manosroi et al., 2011). More than seven thousand medicinal plants species were included into Lanna recipe, which were written in Lanna alphabets (Manosroi et al., 2011).

Comparative ethnobotanical study in Thailand reveals that about 58% of the total species used in this study have not been reported to treat MSD (Kantasrila et al., 2020;

Pongamornkul, 2017). The most important reason, these species are not popularly used due to their taste, rarity. Therefore, there are trend that these species are not chosen to use in the future (Panyadee et al., 2023).

The dominant family and most wildly used for treating MSDs among Thai Yuan people was Acanthaceae, which is also considered to have many important medicinal plants in various region of northern Thailand (Somprasong, Vjarodaya & Chayamarit, 2014). Other commonly used families included Phyllanthaceae, Asteraceae, Fabaceae and Zingiberaceae. Among these families, Asteraceae, Fabaceae and Zingiberaceae were reported the dominant families for treating MSD among Karen people (Kantasrila et al., 2020) and are also used as ethnomedicinal plants in many ethnic groups in Thailand (Phumthum et al., 2018). Moreover, these families are also prevalent in the traditional medicinal practices of other parts of world (Malik et al., 2018; Sreekeesoon & Mahomoodally, 2014).

In terms of plant part used, leaves and stem were the most commonly used in this study. Leaves were reported as the most commonly used part for treating MSD in both Thailand (Kantasrila et al., 2020) and other countries (Malik et al., 2018). This part is easy to prepare for remedies and has high percentages of phytochemical compounds (Amri & Kisangau, 2012; Malik et al., 2018; Ullah et al., 2010). Stems, on the other hand, were popularly used in tree species and are commonly used for medicine in Thailand (Phumthum et al., 2018). Stems can maintain phytochemical compounds for longer time than leaves when harvested (Phumthum et al., 2018). Decoction was a common method used to prepare medicinal plants to treat MSDs, which was also the most used in other ethnobotanical studies (Keter & Mutiso, 2012; Yaseen et al., 2015). Water is a common solvent for preparing medicinal plants due to its easy process and ability to extract the bioactive compounds plants (Kachmar et al., 2021; Yaseen et al., 2015). Burning method was specific to certain plant species and were often used for compressing organ of body. The vast majority of using medicinal plants were taken orally which was related to the dominant mode of preparation. Similar results have been reported in other studies on medicinal plants in Thailand (Phumthum et al., 2018).

2. Important medicinal plant species and Important MSD category

Many important species were found to be used for treating MSDs among Thai Yuan people. In this study, we have calculated UV values to assess the most important species which were those with high UV values indicating high use reports and prevalence among

community (Bennett & Husby, 2008). Three species, including *P. major*, *C. asiaticum* and *E. scaber*, had UV higher than 0.5 and should be prioritize for future detailed pharmacological activity studies for MSD.

Plantago major, also known as "Ya En Yeud," was the most important species for treating MSDs, and is commonly found in home gardens (Panyadee et al., 2019). Literature review on medicinal plants used for MSDs showed that *P. major* was commonly used in many ethnic groups of Thailand for many ailments, especially MSDs (Anderson, 1993; Areekun, 1978). The leaves of *P. major* were burned and used to compress the body for treating fractured bone (Pongamornkul, 2010), muscle pains (Pongamornkul, 2010), back pain (Supawimolpan, 2011), and sprain (Inta, Trisonthi & Trisonthi, 2011; Pongamornkul, 2003; Srithi, 2012). Pharmacological studies have shown that iridoids in this plant are related to anti–inflammatory activity and have potential to treat MSDs (de Padua, 1999; Turel et al., 2009).

Crinum asiaticum is another popular plant used for medicinal purpose in Thailand. For MSD, it has been reported to use for treating fracture bone (Pipitkul, 2001; Srithi, 2012; Tovaranonte, 1998), muscle pain (Pongsattayapipat, 1992; Srithi, 2012), sprain (Kamwong, 2009; Panyadee, 2012; Pipitkul, 2001) osteoarthritis (Kongkwamcharoen et al., 2021), and joint pain (Srithi, 2012). In other countries, *C. asiaticum* is also used as a folk medicine for treating many MSD ailments. In Malaysia, it is used for rheumatic remedies (Samud et al., 1999), while in Philippines, its leaves are prepared to treat inflamed joints and sprains (Valenzuela, Guevara & Garcia, 1930). Pharmacological studies have shown that *C. asiaticum* is rich in alkaloids with potential anti–inflammatory (Kongkwamcharoen et al., 2021; Samud et al., 1999) and anti–oxidative activities (Ghane et al., 2018).

Elephantopus scaber is an ethnomedicinal plant that is used in many countries such as China (Wang et al., 2014), and Thailand (Kantasrila et al., 2020). This species is widely used as tonic in Thailand, and many ethnic groups used it to treat knee pain (Inta, 2014), back pain (Sukkho, 2008), and muscular pain (Kantasrila et al., 2020; Srithi, 2012). The bioactive compound of *E. scaber* such as flavonoids, tannin, and saponins have potential anti–inflammatory properties (Kabeer & Prathapan, 2014; Nurtamin, Sudayasa & Tien, 2018; Wang et al., 2014).

The identification of previously unreported medicinal plants used by the Thai Yuan people for treating MSDs not only expands the current ethnobotanical knowledge in Thailand, but also presents new opportunities for drug discovery and development (Inta, Trisonthi &

Trisonthi, 2013). As the interest in traditional medicine grows globally, this study's findings could contribute to the ongoing search for effective natural remedies and pharmacological treatments. Investigating the bioactive compounds and mechanisms of action of these plants may lead to the development of novel therapeutic strategies for managing MSDs, ultimately benefiting patients worldwide (Cavero & Calvo, 2015; Malik et al., 2018; Rathi & Rathi, 2020).

It should be noted that some plants that had only one use report in this study, such as *Centella asiatica* (L.) Urb., *Betula alnoides* Buch.–Ham. ex D.Don, *Curcuma longa* L., *Cymbopogon citratus* (DC.) Stapf, and *Sambucus javanica* Reinw. Ex Blume, are very important for treating MSDs in other ethnic groups of Thailand (Kantasrila et al., 2020). This suggests that the Thai Yuan have unique knowledge that has been passed down from their ancestors over time.

To validate traditional knowledge, the informant consensus factor was calculated to select the species for each ailments category (Canales et al., 2005). Additionally, ICF were used to determine the agreement among the informants in selecting plants to treat each ailment category (Uddin & Hassan, 2014). High ICF values species are assumed as good candidates for bioactive compound study (Uddin & Hassan, 2014). Among the MSD categories, the sprain/strain of joint NOS had the highest informant consensus factor value. The species responsible for this high consensus were C. *asiaticum* L., *Catunaregam spathulifolia* Tirveng., and *P. major* L.

Another important category of MSD for Thai Yuan was muscle pain, which had the highest use reports and number of species. The prominent species responsible for this high consensus were *P. major* L., *C. asiaticum* L. and *E. scaber* L. These plants had high use reports and were commonly used for MSD treatment in many ethnic groups in Thailand. This prevalence indicates that these plants play a critical role in MSD treatment, thereby making them suitable candidates for future exploration of their phytochemical compounds and potential pharmaceutical development. Moreover, this study holds promise for the use of these plants as complementary and alternative medicine for the treatment of MSDs in both the Thai Yuan community and other populations in Thailand.

Medicinal plants and herbal remedies have been regarded as pure, safe, healthful, and cost–effective alternatives to modern medicine, given their natural origins (Payyappallimana, 2010; van Wyk & Prinsloo, 2020). Therefore, this study adds value for the existing body of

knowledge on treating MSDs. Furthermore, these plants could be chosen for further investigation of their pharmacological activities and clinical trials with the ultimate aim of developing commercial products.

The results of this study highlight the need for increased collaboration between traditional practitioners and modern scientists in the field of ethnobotany. By combining the deep–rooted knowledge and practices of Thai Yuan people with scientific research methods, it becomes possible to validate the efficacy and safety of these medicinal plants, as well as to optimize their use for treating MSDs. This interdisciplinary approach would not only help preserve the traditional knowledge and biodiversity of the region but also ensure that the potential therapeutic benefits of these plants are harnessed and made accessible to a wider population.

CONCLUSION

Despite the advancements of modern medicine, traditional medicine still holds an important place in the lives of Thai Yuan people. The knowledge of medicinal plants has been passed down through generations, and this study identified 138 species from 53 families that are used to treat MSD. The dominant families were Acanthaceae, Phyllanthaceae, Asteraceae and Fabaceae with leaves and stems being the most commonly used parts. The MSDs were grouped into 17 ailment categories, with muscle pain, flank/axilla symptom/complaint, back symptom/complaint, and knee symptom/complaint being the most commonly reported. Important species with high UV were *P. major* L., *C. asiaticum* L., and *E. scaber* L. which are potential candidates for further pharmacological and clinical studies for treating MSD. This study highlights the significance of these important plants and recommends promoting their sustainable utilization. This approach contributes to the conservation of medicinal plants that may be lost in the future due to changing lifestyle. Moreover, these medicinal plants represent alternative treatment option for MSDs alongside modern medicine, emphasizing the value of integrating traditional knowledge with contemporary healthcare practices for a global audience.

REFERENCES

Amri, E., & Kisangau, D.P. (2012). Ethnomedicinal study of plants used in villages around Kimboza forest reserve in Morogoro, Tanzania. **Journal of Ethnobiology and Ethnomedicine, 8**(1), 1–9.

Anderson, E.F. (1993). **Plant and People of the Golden Triangle: Ethnobotany of the Hill Tribes of the Northern Thailand**. Portland, Oregon: Whitman College and Desert Botanical Garden.

Areekun, S., & Onlamun, A. (1978). **Food plants and medicinal plants of ethnic groups in Doi Ang Khang, Chiang Mai (In Thai)** (Research report). Bangkok: Kasetsart University.

Arnold, M.D., & Thornbrough, L.M. (1999). Treatment of musculoskeletal pain with traditional Chinese herbal medicine. **Physical Medicine and Rehabilitation Clinics of North America, 10**(3), 663–671.

Bennett, B.C., & Husby, C.E. (2008). Patterns of medicinal plant use: an examination of the Ecuadorian Shuar medicinal flora using contingency table and binomial analyses. **Journal of Ethnopharmacology, 116**(3), 422–430.

Bodeker, G., & Burford, G. (2005). Medicinal plant biodiversity and local healthcare: sustainable use and livelihood development. **Traditional, complementary, and alternative medecine: Policy and public health perspectives. Imperial College Press, London**, 145–166.

Canales, M., Hernández, T., Caballero, J., De Vivar, A.R., Avila, G., Duran, A., & Lira, R. (2005). Informant consensus factor and antibacterial activity of the medicinal plants used by the people of San Rafael Coxcatlán, Puebla, México. **Journal of Ethnopharmacology, 97**(3), 429–439.

Carocho, M., & Ferreira, I. (2013). The role of phenolic compounds in the fight against cancer–a review. **Anti–Cancer Agents in Medicinal Chemistry (Formerly Current Medicinal Chemistry–Anti–Cancer Agents), 13**(8), 1236–1258.

Cavero, R.Y., & Calvo, M.I. (2015). Medicinal plants used for musculoskeletal disorders in Navarra and their pharmacological validation. **Journal of Ethnopharmacology, 168**, 255–259.

Cieza, A., Causey, K., Kamenov, K., Hanson, S.W., Chatterji, S., & Vos, T. (2020). Global estimates of the need for rehabilitation based on the Global Burden of Disease study 2019: a systematic analysis for the Global Burden of Disease Study 2019. **The Lancet, 396**(10267), 2006–2017.

de Padua, L.S., Bubypraphatsara, N. & Lemmens, R.H.M.J (1999). **Plant Resources of South–East Asia No.** 12(1): **Medicinal and Poisonous Plants I.** Leiden, the Netherlands: Backhuys Publishers.

Ghane, S., Attar, U., Yadav, P., & Lekhak, M. (2018). Antioxidant, anti–diabetic, acetylcholinesterase inhibitory potential and estimation of alkaloids (lycorine and galanthamine) from Crinum species: An important source of anticancer and anti–Alzheimer's drug. **Industrial crops and products, 125**, 168–177.

Holmberg, S., Stiernström, E.–L., Thelin, A., & Svärdsudd, K. (2002). Musculoskeletal symptoms among farmers and non–farmers: a population–based study. **International Journal of Occupational and Environmental Health, 8**(4), 339–345.

Inta, A. (2011). **Analysis of Traditional Knowledge of Plants Used of the Communities in the Haripunchai Campus, Chiang Mai University, Lamphun Province** (Research report). Chiang Mai: Chiang Mai University.

Inta, A., Trisonthi, C., & Trisonthi, P. (2011). **An analysis of knowledge on the utilization of local plants of Chiang Mai University Hariphunchai Education Centre,Lamphun Province, Chiang Mai University** (Research report). Chiang Mai: Chiang Mai University.

Inta, A., Trisonthi, P., & Trisonthi, C. (2013). Analysis of traditional knowledge in medicinal plants used by Yuan in Thailand. **Journal of Ethnopharmacology, 149**(1), 344–351.

Inta, A. (2014). **A Comparative Study of Ethnobotany of Ethnic groups in Pang Mapha District, Maehongson Province** (Research report). Chiang Mai:, Thailand: Chiang Mai University.

Inta, A., Srisanga, P., Panyadee, W., Pongamornkul, N., Kongphuthorn, T., Boonrasri, W., Tanattang, N., Chaisoung, K., Punchay, P., Somjaiai, B., Kongkaew, N., Sutjaritjai, S., Kaewsangsai, R., Kantasrila, P., Samridpium, & Katechai, P. (2018). **Survey of biodiversity: A case study of medicinal plants in Nan and Mae Hong Son community forest**. Chiang Mai: Wanida printing.

Kabeer, F.A., & Prathapan, R. (2014). Phytopharmacological Profile of Elephantopus scaber. **Pharmacologia, 2**, 272–285.

Kachmar, M.R., Naceiri Mrabti, H., Bellahmar, M., Ouahbi, A., Haloui, Z., El Badaoui, K., Abdelhakim, B., & Chakir, S. (2021). Traditional knowledge of medicinal plants used in the Northeastern part of Morocco. **Evidence–Based Complementary and Alternative Medicine,** 2021.

Kamwong, K. (2009). **Ethnobotany of Karens at Ban Mai Sawan and Ban Huay Pu Ling, Ban Luang Sub–District, Chom Thong District, Chiang Mai Province.** (Master of Science (Biology)). Chiang Mai University. Thailand.

Kantasrila, R., Pongamornkul, W., Panyadee, P., & Inta, A. (2017). Ethnobotany of medicinal plants used by Karen, Tak province in Thailand. **Thai Journal of Botany, 9**(2), 193–216.

Kantasrila, R., Pandith, H., Balslev, H., Wangpakapattanawong, P., Panyadee, P., & Inta, A. (2020). Medicinal Plants for Treating Musculoskeletal Disorders among Karen in Thailand. **Plants, 9**(7), 811.

Kantasrila, R. (2021). **Ethnobotanical Study of Medicinal Plants for Treating Musculoskeletal Disorders Among Skaw Karen in Chiang Mai, Thailand.** (Doctor of Philosophy (Biodiversity and Ethnobiology)). Chiang Mai University. Thailand.

Keter, L.K., & Mutiso, P.C. (2012). Ethnobotanical studies of medicinal plants used by Traditional Health Practitioners in the management of diabetes in Lower Eastern Province, Kenya. **Journal of Ethnopharmacology, 139**(1), 74–80.

Khuankaew, S., Srithi, K., Tiansawat, P., Jampeetong, A., Inta, A., & Wangpakapattanawong, P. (2014). Ethnobotanical study of medicinal plants used by Tai Yai in Northern Thailand. **Journal of Ethnopharmacology, 151**(2), 829–838.

Kongkwamcharoen, C., Itharat, A., Pipatrattanaseree, W., & Ooraikul, B. (2021). Effects of Various Preextraction Treatments of Crinum asiaticum Leaf on Its Anti–Inflammatory Activity and Chemical Properties. **Evidence–Based Complementary and Alternative Medicine,** 2021.

Luangwilai, T., Norkaew, S., & Siriwong, W. (2014). Factors associated with musculoskeletal disorders among rice farmers: cross sectional study in Tarnlalord sub–district, Phimai district, Nakhonratchasima province, Thailand. **Journal of Health Research, 28(**Suppl.), S85–S91.

Malik, K., Ahmad, M., Zhang, G., Rashid, N., Zafar, M., Sultana, S., & Shah, S.N. (2018). Traditional plant based medicines used to treat musculoskeletal disorders in Northern Pakistan. **European Journal of Integrative Medicine, 19**, 17–64.

Manosroi, J., Moses, Z.Z., Manosroi, W., & Manosroi, A. (2011). Hypoglycemic activity of Thai medicinal plants selected from the Thai/Lanna Medicinal Recipe Database MANOSROI II. **Journal of Ethnopharmacology**, 138(1), 92–98.

Manosroi, J., Sainakham, M., Manosroi, W., & Manosroi, A. (2012). Anti–proliferative and apoptosis induction activities of extracts from Thai medicinal plant recipes selected from MANOSROI II database. **Journal of Ethnopharmacology, 141**(1), 451–459.

Manosroi, A., Akazawa, H., Akihisa, T., Jantrawut, P., Kitdamrongtham, W., Manosroi, W., & Manosroi, J. (2015). In vitro anti–proliferative activity on colon cancer cell line (HT–29) of Thai medicinal plants selected from Thai/Lanna medicinal plant recipe database "MANOSROI III". **Journal of Ethnopharmacology, 161**, 11–17.

Nurtamin, T., Sudayasa, I.P., & Tien, T. (2018). In Vitro Anti–Inflammatory Activities of Ethanolic Extract Elephantopus Scaber Leaves. **Journal Kedokteran Dan Kesehatan Indonesia, 9**(1), 46–52.

Ong, H.G., Ling, S.M., Win, T.T.M., Kang, D.–H., Lee, J.–H., & Kim, Y.–D. (2018). Ethnobotany of wild medicinal plants used by the Müün ethnic people: A quantitative survey in southern Chin state, Myanmar. **Journal of herbal medicine, 13**, 91–96.

Pantarod, B. (2002). **A Survey and Collection of Medicinal Plants at Na Kwang Village, Bo Kleua District, Nan Province.** (Master of Science (Biology)). Chiang Mai University. Thailand.

Panyadee, P. (2010). **Plant Utilization and Communitiy Forest Management in Sri Bua Ban village, Sir Bua Ban Sub–district, Mueang District, Lamphun Province.** (Bachelor of Science (Biology)). Chiang Mai University. Thailand.

Panyadee, P. (2012). **Plant Diversity in Homegardens of Tai Yai Communities in Pang Mapha District, Mae Hong Son Province.** (Master of science). Chiang Mai University. Thailand.

Panyadee, P. (2017). **Comparison of Plants Composition and Structure of Homegardens of Ethnic Groups in Chiang Mai Province, Thailand.** (Doctor of Philosophy (Biodiversity and Ethnobiology)). Chiang Mai University. Thailand.

Panyadee, P., Balslev, H., Wangpakapattanawong, P., & Inta, A. (2019). Medicinal plants in homegardens of four ethnic groups in Thailand. **Journal of Ethnopharmacology, 239**, 111927.

Panyadee, P., Wangpakapattanawong, P., Inta, A., & Balslev, H. (2023). Very High Food Plant Diversity among Ethnic Groups in Northern Thailand. **Diversity, 15**(1), 120.

Parrotta, J. (2002). **Conservation and sustainable use of medicinal plant resources—an international perspective**. Paper presented at the Invited Papers Presented at the World Ayurveda Congress, Kochi, Kerala.

Payyappallimana, U. (2010). Role of traditional medicine in primary health care: an overview of perspectives and challenging. **Yokohama Journal of Social Sciences**, 14(6), 723–743.

Phumthum, M., Srithi, K., Inta, A., Junsongduang, A., Tangjitman, K., Pongamornkul, W., Trisonthi, C., & Balslev, H. (2018). Ethnomedicinal plant diversity in Thailand. **Journal of Ethnopharmacology, 214**, 90–98.

Phumthum, M., Balslev, H., Kantasrila, R., Kaewsangsai, S., & Inta, A. (2020). Ethnomedicinal Plant Knowledge of the Karen in Thailand. **Plants, 9**(7), 813.

Pipitkul, S. (2001). **Medicinal Plant Utilization for the Living of Hill Tribes at Doi Musoe, Tak Province.** (Master of Science). Mahidol University. Thailand.

Pongamornkul, W. (2003). **An Ethnobotanical Study of the Karen at Ban Yang Pu Toh and Ban Yang Thung Pong, Chiang Dao District, Chiang Mai Province.** (Master of Science (Biology)). Chiang Mai University. Thailand.

Pongamornkul, W. (2010). **Survey and Collection of Medicinal Plants and Traditional Plants of the Ethnic Groups in Nothern of Thailand: Annual performance report** 2010. Thailand: The Botanical Garden Organization, Ministry of Natural Resources and Environment.

Pongamornkul, W. (2017). **Northern Thailand Ethnobotanical index**. Thailand: Wanida Karnpim Limited Partnership.

Pongsattayapipat, R. (1992). **Ethnobotanical study of the Hmong Khao, Chang Khian village, Chiang Mai Province.** (Special problem). Chiang Mai University. Thailand.

Pooma, R., & Suddee, S. (2014). **Tem Smitinand's Thai Plant Names, Revised**. Bangkok, Thailand: The Office of the Forest Herbarium, Department of National Parks, Wildlife and Plant Conservation.

Prabhu, S., Vijayakumar, S., Yabesh, J.M., Prakashbabu, R., & Murugan, R. (2021). An ethnobotanical study of medicinal plants used in pachamalai hills of Tamil Nadu, India. **Journal of herbal medicine, 25**, 100400.

Rathi, B., & Rathi, R. (2020). Quantitative Analysis of Medicinal plants used by the Traditional healers of Karanja block of Wardha district for treating Musculoskeletal disorders. **International Journal of Ayurvedic Medicine, 11**(2), 175–183.

Reyes-García, V., Huanca, T., Vadez, V., Leonard, W., & Wilkie, D. (2006). Cultural, practical, and economic value of wild plants: a quantitative study in the Bolivian Amazon. **Economic Botany, 60**(1), 62–74.

Royal Forest Department (RFD). (2022). **Executive summary** 2022: **Forest area information project** (R.F.D. Forest Land Manangment Office Ed.). Forest Land Manangment Office, Royal Forest Department: Ministry of Natural Resources and Environment.

Samud, A.M., Asmawi, M.Z., Sharma, J.N., & Yusof, A.P.M. (1999). Anti-inflammatory activity of Crinum asiaticum plant and its effect on bradykinin-induced contractions on isolated uterus. **Immunopharmacology, 43**(2-3), 311–316.

Sancho, R., Lucena, C., Macho, A., Calzado, M.A., Blanco-Molina, M., Minassi, A., . . . & Muñoz, E. (2002). Immunosuppressive activity of capsaicinoids: capsiate derived from sweet peppers inhibits NF-**K**B activation and is a potent antiinflammatory compound in vivo. **European Journal of Immunology, 32**(6), 1753–1763.

Sombatsawat, E., Luangwilai, T., Ong-Artborirak, P., & Siriwong, W. (2019). Musculoskeletal disorders among rice farmers in Phimai District, Nakhon Ratchasima Province, Thailand. **Journal of Health Research, 33**(6), 494–503.

Somprasong, W., Vjarodaya, S., & Chayamarit, K. (2014). Taxonomic Study of the Family Acanthaceae used as traditional medicinal plants for ethnic groups in North, Central and Northeastern Thailand. **Thai Agricultural Research Journal, 32**(1), 77-88.

Songsangchun, A. (2015). **Plants Usages of Khon Muang and Lawa in Phu Fah Subdistrict, Bo Klua District, Nan Province.** (Master of science). Chiang Mai University. Thailand.

Sreekeesoon, D.P., & Mahomoodally, M.F. (2014). Ethnopharmacological analysis of medicinal plants and animals used in the treatment and management of pain in Mauritius. **Journal of Ethnopharmacology, 157**, 181–200.

Srithi, K. (2012). **Comparative ethnobotany in Nan province, Thailand.** (Doctor of Philosophy). Chiang Mai University. Thailand.

Sukkho, T. (2008). **A Survey of Medicinal Plants Used by Karen People at Ban Chan and Chaem Luang Subdistricts, Mae Chaem District, Chiang Mai Province.** (Master of Science (Biology)). Chiang Mai University. Thailand.

Sumridpiem, P. (2017). **Utilization Analysis of Medicinal Plants Among Tai Yong And Tai Yuan in Lamphun Province.** (Master of Science (Biology)). Chiang Mai University. Thailand.

Supawimolpan, W. (2011). **Ethnobotany of Khamu in Ban Huai Sa Taeng, Thung Chang District, Nan Province.** (Bachelor's degree). Chiang Mai University. Thailand.

Suthakul, P. (2002). **Plant utilization in Thung Yao communitiy forest, Sri Bua Ban sub-district, Mueang District, Lamphun province.** (Bachelor of Science). Chiang Mai University. Thailand.

Tovaranonte, J. (1998). **Ethnobotany Study of the Tai Lue, Hmong and Yao in Some Areas of Nan Province.** (Master's Thesis). Chiang Mai University. Thailand.

Tovaranonte, J. (2001). **Ethnobotany in Surroundings Area of Mae Fah Luang University. School of Science, Mae Fah Luang University** (Research report). Chiang Rai: Mae Fah Luang University.

Trisonthi, C., Trisonthi, P., Wangpakapattanawong, P., & Srisanga, P. (2007). **Research Project on Gathering of Highland Traditional Biodiversity– and Ethnobiology–Based Knowledge** (Research report). Chiang Mai: Chiang Mai University.

Trotter, R.T. & Logan, M.H. (1986). **Informant consensus: a new approach for identifying potentially effective medicinal plants**. Redgrave Publishing Company, Bedfort Hill, New York: Plants in Indigenous Medicine and Diet, Behavioural Approaches.

Turel, I., Ozbek, H., Erten, R., Oner, A.C., Cengiz, N., & Yilmaz, O. (2009). Hepatoprotective and anti–inflammatory activities of Plantago major L. **Indian journal of pharmacology, 41**(3), 120.

Uddin, M.Z., & Hassan, M.A. (2014). Determination of informant consensus factor of ethnomedicinal plants used in Kalenga forest, Bangladesh. **Bangladesh Journal of Plant Taxonomy, 21**(1), 83–91.

Ullah, R., Hussain, Z., Iqbal, Z., Hussain, J., Khan, F.U., Khan, N., Muhammad, Z., Ayaz, S., Ahmad, S. & Rehman, N.U. (2010). Traditional uses of medicinal plants in Darra Adam Khel NWFP Pakistan. **Journal of Medicinal Plants Research, 4**(17), 1815–1821.

Valenzuela, P., Guevara, R., & Garcia, S. (1930). Lansium domesticum correa: a study of the chemistry of the rind and the pharmacodynamics of the resin obtained there. **Natural Applied Science of Bulletin, 1**, 71–91.

van Wyk, A.S., & Prinsloo, G. (2020). Health, safety and quality concerns of plant–based traditional medicines and herbal remedies. **South African Journal of Botany**, 133, 54–62.

Varipo, W. (2012). **Ethnobotany of Ban Pok Village, Samoeng District, Chiang Mai Province.** (Bachelor of Science (Biology)). Chiang Mai University. Thailand.

Ved, D., & Goraya, G. (2007). Demand and supply of medicinal plants in India. **NMPB, New Delhi & FRLHT, Bangalore, India**.

Wang, J., Li, P., Li, B., Guo, Z., Kennelly, E. J., & Long, C. (2014). Bioactivities of compounds from *Elephantopus scaber,* an ethnomedicinal plant from southwest china. **Evidence–Based Complementary and Alternative Medicine,** 2014.

World Health Organization (WHO). (2022). **Musculoskeletal health**. Retrieved from January, 31, 2023, from https://www.who.int/news–room/fact–sheets/detail/musculoskeletal–conditions.

Wonca International Classification Committee (WICC). (2005). **International Classification of Primary Care. (**2nd Edition). Oxford University Press, Oxford: Wonca International Classification Committee (WICC).

Yaseen, G., Ahmad, M., Zafar, M., Sultana, S., Kayani, S., Cetto, A.A., & Shaheen, S. (2015). Traditional management of diabetes in Pakistan: ethnobotanical investigation from traditional health practitioners. **Journal of Ethnopharmacology, 174**, 91–117.