Medicinal plants used in the treatment of diabetes in Karo ethnic, North Sumatra, Indonesia

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Abstract. Medicinal plants derived from traditional medicines have played an important role in managing a variety of healthcare and diseases in Karo ethnic in North Sumatra, Indonesia. The study aimed to document the ethnomedical information on medicinal plants used by traditional healers of Karo ethnic in the treatment of diabetes and to assess the crude extract of phytochemical constituents qualitatively from medicinal plant organs. The study was conducted on two Karo sub-ethnic living at the highland (Karo Gugung) in Karo Regency and the lowland (Karo Jahe) in Langkat Regency with the length of the study was eight months of observation. The survey was conducted using open-ended interviews among four traditional healers those who were selected by snowball sampling method; quantitative analysis of ethnomedical data was performed by calculating the familiarity index (Fi). Fresh plant samples which were used for phytochemical analysis were collected using participatory method. The results showed that 15 plants were used to treat diabetes by Karo traditional healers. The plants are Blumea balsamifera, Nypa fruticans, Bischofia javanica, Eleutherine americana, Allium cepa, A. sativum, Eugenia polyantha, Piper betle, P. nigrum, Citrus aurantiifolia, Boesenbergia pandurata, Curcuma longa, Kaempferia galanga, Zingiber montanum, and Z. officinale. Familiarity index (Fi) value of each plant was 25 which explained that each of medicinal plant was used by only one traditional healer. The phytochemical screening showed that the crude plant extracts contained phenolic, terpenoid, steroid, and saponin.

Keywords: Etnobotany, phytochemistry, traditional medicine

1. Introduction
Use of ethnomedical information in medicinal plant research has gained attention among the scientific community for the past few decades [1,2]. Herbal medicine showed an exponential growth and are gaining popularity in many countries in the present days because of their natural origin and fewer side effects [3]. Diabetes is the most current health problem in the world [4]. Diabetes is a chronic progressive metabolic disorder with life threatening complications including cardiovascular diseases, retinopathy, nephropathy, neuropathy which may eventually lead to death [5] and characterized by high blood glucose levels [6]. High blood glucose levels is either as a result of
insufficient endogenous insulin production by the pancreatic beta cells (otherwise known as type-1 diabetes); or impaired insulin secretion and/or action (type-2 diabetes). Type-1 diabetes is an autoimmune disease characterized by T-cell mediated destruction of the pancreatic beta cells. In type-2 diabetes, there is a gradual development of insulin resistance and beta cell dysfunction, strongly associated with obesity and a sedentary lifestyle [6,7]. Changes in human behavior and lifestyle over the last century have resulted in a dramatic increase on the incidence of diabetes worldwide [8]. The world prevalence of diabetes in the present days is 9% [4] and the incidence which was predicted among adults (aged 20-79) will increase from 6.4% in 2010 to 7.7% by 2030 and there will be 69% increase in numbers of adults with diabetes in developing countries and a 20% increase in developed countries [9].

Insulin injection and hypoglycemic agents are essential and effective drugs for diabetes mellitus, but these compounds possess several adverse effects and have no effects on diabetes complications in the long term [10]. Complication is the major cause of morbidity and mortality in diabetes and management of diabetes without any side effects is still a challenge to the medical system [11]. In recent years, some studies have been conducted on the use of herbal/natural products in diabetes [4,12]. Most of the world population used traditional medicines for healthcare and medicine because of more effective, safe, and easy access [11]. Based on estimation opined by World Health Organization, more than three-quarters of population of developing nations use herbal medicine for their primary health care [13]; and various medicinal plants derived from traditional medicine have played important role in the treatment of various diseases in up to 80% of world population [10] and although many currently available drugs that have been derived from plants [11], there is no enough scientific information about some of them [10].

Various plants in nature are an extraordinary source of antidiabetic medicines [14]. Current anti-diabetic drugs as result that were gathered from research and development of anti-diabetic drugs suffer from lack of efficacy and also exert undesirable side effect, there by demanding new remedies [14,5]. Forest degradation as a consequence of forest conversion in many appropriate areas of Sumatra [15] has threatened the existence of medicinal plants used by local community [16]. Most plants used in traditional medicine were collected from the wild and only few are cultivated [2]. In addition, only few traditional healers had apprentice [17]. Hence study of medicinal plants is needed.

Karo ethnic in North Sumatra, Indonesia has possessed a culture of using traditional medicine since a long time ago [18,19]. Karo community lived near the forest with various medicinal plants that played important roles in Karo’s culture [19]. There are still few publications on medicinal plants in managing diabetes used by local community of Karo ethnic, North Sumatra [19,20,21].

Indonesia has come under scrutiny to reveal new information on diabetes remedies. Several parameters have been proposed such as study area and informant for interviews. The objective is to explore the medicinal plants used in the treatment of diabetes. The results are expected to supply the necessary information for the Indonesian Government to reveal new diabetes remedies in developing alternative solutions for managing and controlling diabetes.

2. Methods
2.1. Study area
The study was carried out in three districts consists of Berastagi District in Karo Regency, Merdeka District in Karo Regency, and Sei Bingai District in Langkat Regency, Province of North Sumatra, Indonesia. Geographical location of Karo Regency and Langkat Regency are shown in Figure 1. Karo and Langkat Regency has a tropical climate with two seasons (Karo Regency has first rainy season from August until January, second rainy season at March until May, dry season at January, Juni, and July; Langkat Regency has first rainy season from August until February, second rainy season April and May, dry season at March, Juni, and July). Berastagi and Merdeka are two districts in Karo Regency, Berastagi District is geographically located at 98°28’-98°31’E and 03°10’-03°14’N at a distance of 67 km from Medan, the capital city of North Sumatra, with the elevation of 1.375 meters above sea level, with temperature ranging between 19°C-26°C. Merdeka District is at 98°27’ - 98°31’
E and 03°10’ - 03°14’ N, with elevation of 1.162-1.453 meters above sea level, with temperature ranging between 16°C-17°C, at a distance of 65 km from Medan [22]. Whereas Sei Bingai is a district of Langkat Regency, which is located at 98°28’-98°30E and 03°11’-03°15’N at a distance of 60 km from Medan, with elevation of 106 meters above sea level [23].

Figure 1. Study area location: (A) Sumatra Utara Province position in Indonesia, (B) Karo and Langkat Regency position in Sumatra Utara Province

Karo and Langkat Regency are cities in North Sumatra, Indonesia where Karo ethnic lived [18]. Primary forest in Leuser National Park (TNGL–Taman Nasional Gunung Leuser) encompass area from Province of Aceh until some part of North Sumatra in Karo and Langkat Regency as presented in
Figure 2. Karo people traditional life was connected to plants that were near to their settlement. Karo people’s occupation is mainly farmer [18], but field observation during survey revealed that Karo life style slowly changing to be sedentary life style in recent years because of the alteration of their way to process their cultivation farm by hiring the immigrant.

2.2. Ethnobotanical data collection
Ethnobotanical data were collected using a method similar to Chinsembu (2016) [17]. Interviews were conducted among four traditional healers as respondents; snowball sampling method was used to obtain the respondents who were originated from two villages in Karo Regency representing Karo Gugung Sub ethnic (Karo people living in highland) and the rest two were from Langkat Regency who represented Karo Jahe sub ethnic (Karo people living at lowland). The first respondent of traditional healer was obtained based on information from local people and become key gatekeepers. Key gatekeepers were used to verify the presence of and access to next traditional healer in the study area.

Researcher introduced the team and explained the study to respondent before conducting interviews. Open ended interviews were performed individually with the traditional healer. Data of characteristics and information related to the medicinal use of plants for the management of diabetes were noted and recorded during interviews. Interviews were conducted in Indonesian language (Bahasa Indonesia).

During conversations with respondent of the traditional healer, information about the main symptoms of diabetes, traditional healing practice, and sources of ethnomedicinal knowledge were acquired. The data in relation to the plants were also recorded as follows: Local names, plant habits, plant parts used, the diabetes condition treated with the plants, and the modes of preparation and application of the plant remedies to the patient.

Participatory method was used to gather plants material sample for voucher specimens and crude extract for phytochemical screening. On site identification was conducted to assess familiar plant species. Voucher specimens of all plants were collected in herbarium plant presses and transported to the Herbarium MEDA, Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Sumatra Utara, Indonesia for identification, confirmation, and storage. IPNI (International Plant Name Index) was used to verify the botanical name of plants species. Plant material for crude extract phytochemical screening was weighed about 20 grams of fresh plant material. Phytochemical screening was conducted at Laboratory of Natural Product, Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Sumatra Utara, Indonesia.

2.3. Data analysis
Familiarity index ($Fi$) was used to acquire the quantitative analysis [17]. The $Fi$ is a relative indicator of the familiarity of a plant species, which defined as the frequency of a given plant species mentioned as a medicine divided by the total number of traditional healers interviewed in the study. The $Fi$ was calculated as follows:

$$Fi = \frac{Na}{Nb} \times 100 \quad (1)$$

Where $Na$ is the number of informants that mentions a species as a medicine, and $Nb$ is the total number of respondents.

3. Results and Discussion
The result will be discussed in three subsections; they are traditional healers, ethnobotanical flora, and Phytochemical Screening of Medicinal Plants.

3.1. Traditional healer
Three out of four traditional healers had ever been engaged in some academical research as the respondent before the present study. The traditional healers were aged between 43 until 88 years old. Three out of four traditional healers acquired their medicinal plant knowledge by inheriting from their elder lineage (father or grandfather), whereas the rest received his medicinal plant knowledge from
dreams. Only one traditional healer had an apprentice under his tutelage; the rest had none. Study on herbal medicines used in the treatment of diabetes in Arunachal Himalaya, Northeast Iran reported 76% of traditional healers were aged 40 years and above; 87% of traditional healer accepted their knowledge from their parents [11]. The traditional healers in this study received approximately 100-300 patients in one month. Field observations during survey revealed that the patients choosed to use traditional medicine despite modern medicine were because of the efficacy, low cost, and less side effect.

3.2. Ethnobotanical flora
Information on the plant’s scientific names, local names, families, voucher numbers, habits, frequency indices, and parts used are presented in Table 1. Whereas information on traditional medicine remedies including diabetes severity treated, medicinal plants compositions, modes of preparation and application, other therapy used are presented in Table 2. Of a total fifteen plants were used by the traditional healer to treat diabetes in Karo and Langkat Regency, Sumatra Utara Province, Indonesia. The study revealed that the value of all plants were 25.

Table 1. Plants families, species, habits, part(s) used, and frequency index (Fi) of medicinal remedies in Karo ethnic, Sumatra Utara Province, Indonesia

| No. | Family | Species, local name, voucher number | Plant habit | Part(s) used | Frequency index |
|-----|--------|------------------------------------|-------------|-------------|----------------|
| 1   | Areaceae | Nypa fruticans Wurmb, Ipah, bm02 | Tree        | Leaves     | 25             |
| 2   | Asteraceae | Blumea balsamifera DC., Galunggung, bm01 | Shrub       | Leaves     | 25             |
| 3   | Euphorbiaceae | Bischofia javanica Blume, Cingkam, bm03 | Tree        | Bark       | 25             |
| 4   | Iridaceae | Eleutherine americana Merr. ex K.Heyne, Pia-pia, bm04 | Herb       | Whole part | 25             |
| 5   | Liliaceae | Allium cepa L., Bawang megara, bm05 | Herb       | Bulb       | 25             |
| 6   | Liliaceae | Allium sativum L., Bawang mentar, bm06 | Herb       | Bulb       | 25             |
| 7   | Myrtaceae | Eugenia polyantha Barb.Rodr., Salam, bm07 | Medium tree | Leaves     | 25             |
| 8   | Piperaceae | Piper betle L., Belo, bm09 | Climbing shrub | Leaves | 25             |
| 9   | Piperaceae | Piper nigrum L., Lada, bm08 | Climbing shrub | Fruits | 25             |
| 10  | Rutaceae | Citrus aurantiifolia (Christm.) Swingle, Rimo acem, bm10 | Small tree | Fruits | 25             |
| 11  | Zingiberaceae | Boesenbergia pandurata Schltr., Temu-temu, bm11 | Herb       | Rhizome    | 25             |
| 12  | Zingiberaceae | Curcuma longa L., Kuning gersing, bm12 | Herb       | Rhizome    | 25             |
| 13  | Zingiberaceae | Kaempferia galanga L., Kaciwer, bm13 | Herb       | Rhizome    | 25             |
| 14  | Zingiberaceae | Zingiber montanum Link ex A.Dietr., Kuning gajah, bm14 | Herb       | Rhizome    | 25             |
| 15  | Zingiberaceae | Zingiber officinale Roscoe, bahing megara, bm15 | Herb       | Rhizome    | 25             |

All medicinal plants collected in this study were distributed into 9 families and 12 genera. The highest proportion of plant family was Zingiberaceae (5 species), followed by Liliaceae (2 species) and Piperaceae (2 species). The other plant family had only one species. The highest proportion of plants genera were Allium, Piper, and Zingiber with two species for each genera. Other genera had only one species. The study of the medicinal plants that collected by medicinal plants trader from Kabanjahe traditional market, Karo Regency, North Sumatra reported most of medicinal plants were species from Zingiberaceae family and that study reported seven species were used to treat diabetes [20] aside from the medicinal plants recorded in the present study. Of all plants species reported from that study, only one species (Bischofia javanica Blume, family Euphorbiaceae) was the same reported with in the present study. Another study about diabetes medicinal woody plants in Karo ethnic using
diabetes suffering patients, farmers, local merchants, traditional medicinal processors, and the collectors reported 12 species distributed in 11 families [21]; only one species (*Eugenia polyantha* Barb.Rodr., family Myrtaceae) was the same species compared to the present study. Augmented amount of medicinal plant species reported in the present study with other two studies mentioned above revealed that total of thirty-two diabetes medicinal plants species in Karo ethnic.

Medicinal plants used to treat diabetes in the present study had various habits. 53% of total plants recorded in the present study were herbs, 27% trees, 13% climber, and 7% shrubs. The study of herbal medicines used in the treatment of diabetes mellitus in Arunachal Himalaya reported of 68% from 46 diabetes medicinal plants recorded were herbs and trees, and leaves were the majority part in the herbal formulations [11]. Medicinal plant parts used in diabetes remedies in the present study varies. 33% of plants parts used to treat diabetes in the present study were rhizomes, followed by leaves 27%, fruits 13%, bark 7% and whole parts 7%.

![Primary Forest near Karo and Langkat Regency](image)

**Figure 2.** The primary forest near Karo and Langkat Regency, Sumatra Utara Province, Indonesia

The Familiarity index (*F*_i) value of 25 explained that each plant acquired from the study were used by only one traditional healer. The Familiarity index value of 25 indicated the high biodiversity of flora around the traditional healer settlement. The present study site which was located in the community settlement was near to primary forest as presented in Figure 2. Of all diabetes medicinal plants recorded in the present study, 27% were harvested form the wild. The results were contradictive compared to the data reported from another study that most of the medicinal plants species that were traded by medicinal plants trader in Kabanjahe traditional market, Karo Regency were harvested from the wild [20]. Meanwhile, the report on forest existence progress in Langkat Regency, North Sumatra reported the deforestation in Langkat Regency [24]. Hence the conservation of medicinal plant is needed. The present study recorded that most of the medicinal plants were cultivated because one of the traditional healer used the multi-component herbal formulations, one of which formulated of cultivated plants, the formulations had just being used to treat diabetes since last few months before the present study was conducted. The medicinal remedies which is used to treat diabetes was used to treat wounds and ulcers. The traditional healer has no knowledge on diabetes before; Therefore, the medicinal remedies showed good result in healing the diabetes patient within few months from severe ulcer for the first time when he used the medicinal remedies.
3.3. Ethnopharmacological analysis and medicinal plants crude extract phytochemistry
The traditional healers in the present study diagnosed diabetes by observing symptoms such as excessive and frequent urination, prolonged healing of wounds, polydipsia, polyphagia, weight loss, languid, difficult to concentrate, and blurred vision. Other than that, the traditional healer used the result of diagnosed with blood test laboratory. Hence two of the traditional healers in the present study made the medicinal formulations to treat diabetes based on the blood glucose levels as presented in Table 2. The study on diabetes herbal medicines from India reported that the traditional medicine diagnosed the diabetes patient by observing symptoms such as excessive urination, the presence of sugar in urine and swelling of legs [11].

| No. | Diabetes with blood glucose level condition treated | Plants composition | Preparation and administration | Other therapy |
|-----|----------------------------------------------------|--------------------|--------------------------------|---------------|
| 1.  | < 500 mg/dL                                        | Bischofia javanica Blume | Crushed bark are fermented in nipa palm vinegar, drink concoction | -             |
| 2.  | > 500 mg/dL                                        | Bischofia javanica Blume | Crushed bark along with sweetened condensed milk and palm sugar are boiled in nipa palm vinegar, drink | -             |
| 3.  | Blood glucose level is not determined, but used for diabetes patient with ulcer | Allium cepa L., Allium sativum L., Boesenbergia pandurata Schlr., Citrus aurantiifolia (Christm.) Swingle, Curcuma longa L., Kaempferia galanga L., Piper nigrum L., Zingiber montanum Link ex A.Dietr., and Zingiber officinale Roscoe | Pound all material except Citrus aurantiifolia (Christm.) Swingle at once, add squeezed of Citrus aurantiifolia (Christm.) Swingle fruit, pour in special vessel made from bamboo segment, externally used by rubbing concoction around ulcer, internally used by adding concoction into water and drink | -             |
| 4.  | > 500 mg/dL                                        | Blumea balsamifera DC. | Material is squeezed to drip out the fluid, drink | Reflexology |
| 5.  | < 500 mg/dL                                        | Eugenia polyantha Barb.Rodr., Nypa fruticansWurmb, Piper betle L. | Boil materials in water, drink decoction | Reflexology |
| 6.  | Blood glucose level is not determined              | Eleutherine americana Merr. ex K.Heyne | Boil material in water, drink decoction | Param |

The traditional healers in the present study used the single component recipeherbal formulations and also multi-component formulations as presented in Table 2. Herbal therapy with its richness and complex compounds in plants compositions has always been thought to act on multiple targets on the human body [14]. The modes of remedies processing used by the traditional healer in the present study were fermentation, boiling, pounding, and squeezing. Whereas, the administration of formulations which were applied to the patient in the present study were orally administrated and rubbed to the certain body surface. The study on the usage of fermentation in the administration of herbal medicines reported that the fermentation improved the efficacy or reducing adverse effects of herbal medicines [5]. The traditional healers in the present study announced that the diabetes patients were cured without known side effects. The study on diabetes herbal medicines from India reported that the traditional healer announce that the diabetes patients were cured without any known serious side effect [11]. In addition to the traditional medicines to treat diabetes in this study, the other therapies were applied such as reflexology and param. The traditional healer announced that the used of reflexology gave effect to heal and to stimulate the pancreas in producing insulin. The using of reflexology resulted to activate the body’s own healing system to heal and prevent ill [25].

The phytochemical screening of medicinal plants in the present study revealed that crude extract contained phytochemical compounds such as phenolic, terpenoid, steroid, alkaloid, and saponin (as presented in Table 3). The crude extract that was screened from six medicinal formulations made by Karo traditional healers were phenolic, terpenoid, steroid, and saponin. In case of P. betle L. crude extract, the data was different with the information reported in another study on the antioxidant effect...
of *P. betle* Linn. that major constituent of *P. betle* L. was phenol [26]. The absence of phenol constituent in *P. betle* L. that was shown in the present study because of plant organ sample of belo (*P. betle* L. local name in Karo ethnic) that was acquired randomly without specific kind as the informant (the traditional healer who used *P. betle* L. in his medicinal formulations) explained to the author. Several observations and discussions among Karo people in the study area revealed that there were three kinds of *P. betle* L. used among Karo people which consisted of belo (*sirih*), beluntas, and *sirih merah*. The three kinds of *P. betle* L. aforementioned were similar to each other. Belo (*sirih*) was the one used in typical medicinal formulations in Karo ethnic and was traded widely in the traditional market in Karo ethnic settlements; beluntas and *sirih merah* were usually used as ornamental besides as ingredients in medicinal formulations in Karo ethnic tradition.

**Table 3.** Phytochemical screening result of the medicinal plants used by Karo traditional healers in the treatment of diabetes

| No. | Family      | Species, Karo name          | Part(s) used | Phytochemical constituent                              | References     |
|-----|-------------|------------------------------|--------------|-------------------------------------------------------|----------------|
| 1.  | Arecales    | *Nypa fruticans* Wurmb, Ipah | Leaves       | Phenolic, terpene, steroid, saponin                    |                |
| 2.  | Asteraceae  | *Blumea balsamifera* DC.,   | Leaves       | Phenolic, terpene, steroid                            |                |
|     |             | Galunggung                   |              |                                                       |                |
| 3.  | Euphorbiaceae| *Bischofia javanica* Blume, Cingkam | Stem bark    | Phenolic, terpene, steroid, alkaloid, saponin         |                |
|     |             |                              | Root bark    | Phenolic, terpene, steroid, alkaloid                  |                |
| 4.  | Iridaceae   | *Eleutherine americana* Merr. ex K.Heyne, *Pia-pia* | Bulb         | Phenolic, terpene, steroid, alkaloid, saponin         |                |
|     |             |                              | leaves       | Phenolic, terpene, steroid, alkaloid                  |                |
| 5.  | Liliaceae   | *Allium cepa* L., *Bawang megara* | Bulb         | Phenolic, terpene, steroid, alkaloid                  |                |
| 6.  |              | *Allium sativum* L., *Bawang mentar* | Bulb         | Terpene, steroid, alkaloid                            |                |
| 7.  | Myrtaceae   | *Eugenia polyantha* Barb.Rodr., Salam | Leaves       | Phenolic, terpene, steroid, alkaloid                  |                |
| 8.  | Piperaceae  | *Piper betle* L., Belo       | Leaves       | terpene, steroid, saponin                             | Gulcin, 2005; Nahak & Sahu, 2011 |
| 9.  |              | *Piper nigrum* L., *Lada*    | Fruits       | Phenolic, terpene, steroid, alkaloid                  |                |
| 10. | Rutaceae    | *Citrus aurantiifolia* (Dhrism.) | Fruits       | Phenolic, terpene, steroid, alkaloid                  |                |
| 11. | Zingiberaceae| *Bosenbergia pandurata* Schltr., Temu-temu | Rhizome     | Phenolic, terpene, steroid, alkaloid                  |                |
|     |             |                              | Root         | Terpene, steroid                                     |                |
| 12. |              | *Curcuma longa* L., *Kuning gersing* | Rhizome     | Phenolic, terpene, steroid, alkaloid, saponin         |                |
| 13. |              | *Kaempferia galanga* L., *Kaciwer* | Rhizome     | Terpene, steroid, alkaloid                            |                |
| 14. |              | *Zingiber montanum* Link ex A.Dietr., *Kuning gajah* | Rhizome     | terpene, steroid, alkaloid, saponin                   |                |
| 15. |              | *Zingiber officinale* Roscoe, *Bahing megara* | Rhizome     | terpene, steroid, alkaloid, saponin                   |                |
4. Conclusions
The present study revealed that community in Karo and Langkat Regency still used the traditional medicine in the treatment of diabetes and other ailments or diseases. The traditional healer harvested the medicinal plants from the wild and the deforestation were two things that threatened the existence of the medicinal plants and the traditional medicine itself. Hence the preserving of the traditional medicines knowledge and the cultivation of medicinal plants are important for the conservation of traditional medicines. The phytochemical screening result of diabetes herbal formulations made by Karo ethnic traditional healer in the treatment of diabetes were phenolic, terpenoid, steroid, and saponin. The efficacy and safety of all the reported plants with antidiabetic potential in the present study need to be evaluated for phytochemical and pharmacological studies in the further experimental investigations such as to determine the dosages, minimum inhibitory concentrations, bioactive compounds, and toxicities.

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