

Plants with Antidiabetic Efficacy among the Dayak Bidayuh Community, Sanggau Regency, West Kalimantan, Indonesia

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ABSTRACT

Introduction: The use of medicinal plants for diabetes mellitus has been practiced for generations by the Dayak communities in West Kalimantan, Indonesia. The aim of this study is to inventory and describe the utilization of medicinal plants for diabetes mellitus by the Dayak Bidayuh Kerambay, Dayak Golik, and Dayak Sinangkan't communities in Sekayam, Beduai, and Entikong Districts, Sanggau Regency, West Kalimantan, Indonesia. **Method:** This research is a qualitative descriptive study using triangulation method combining interview, observation, and documentation techniques of anti-diabetic mellitus medicinal plants among the Dayak communities. **Results:** The plants used as anti-diabetic mellitus include *Physalis angulata* L., *Ageratum conyzoides* L., *Piper betle* L., *Dillenia suffruticosa* (Griff.) Martelli, *Syzygium polyanthum* (Wight) Walp. *Stenochlaena palustris* (Burm.f.) Bedd, *Gynura procumbens* (Lour.) Merr, *Curcuma domestica* Valetton, *Zingiber officinale* Rosc., *Eleutherine palmifolia* (L.) Merr, *Curcuma zedoaria* (Christm.) Roscoe, *Orthosiphon stamineus* B., *Nepenthes* sp., *Solanum torvum* Swartz, *Garcinia mangostana* L. The plant parts most commonly used, in sequence, are leaves, rhizomes, roots, fruits, fruit peels, and sometimes the entire plant. The method of preparation for each type of plant is the same, which involves boiling and consuming the boiled decoction. **Summary:** There are 15 types of plants used by the Dayak tribe community to address diabetes mellitus. Among these 15 types of plants, different parts are utilized, while the processing method remains the same, which is boiling.

Keywords: Diabetes mellitus, Dayak Bidayuh Tribe, Medicinal Plants.

INTRODUCTION

Indonesia is abundant in biodiversity, particularly in plants known for their medicinal uses. Among Indonesia's estimated 30,000-40,000 plant species, 2,000-7,500 are recognized for their medicinal benefits¹⁻³. Indonesian communities utilize these medicinal plants for treating various illnesses. The use of plants for traditional medicine in Indonesia dates back to ancient times, practiced by ancestors^{4,5}. This utilization of traditional medicinal plants persists as a cultural practice found in different regions, passed down through generations via oral tradition and often known only to specific individuals such as tribal leaders, village heads, elders, and local healers within communities or specific ethnic groups^{6,7}.

Indonesia exhibits diverse ethnicities, cultures, and languages, all highly valuing customs and traditions across various regions^{8,9}. Kalimantan, known for its natural beauty and local wisdom, is home to numerous ethnic groups and cultures, including the Dayak tribes of West Kalimantan, Indonesia, who uphold strong customs and cultural heritage¹⁰⁻¹².

The Dayak tribe is believed to have originated from the "dayakid," a migration wave that pushed individuals in large or small groups into the interior of Kalimantan, Indonesia, leading to their transformation into isolated communities with enduring customs and traditions^{13,14}. The Dayak tribe is prominent in West Kalimantan and is further divided into several smaller sub-groups. The four largest Dayak tribes in West Kalimantan, Indonesia, include the Klematan, Ibanic, Bidayuh,

and Kanyanic. The largest Dayak Bidayuh tribe resides in the Bengkayang and Sanggau areas of West Kalimantan, Indonesia^{15,16}. In Sanggau Regency, Indonesia, the Dayak Bidayuh are divided into three groups: Kerambay, Golik, and Sinangkan't. The Dayak Bidayuh possess local potential in the form of utilizing plants for traditional medicine, a practice preserved to this day, particularly in treating diseases such as diabetes mellitus (DM) using herbal remedies^{17,18}.

Diabetes mellitus is a non-infectious endocrine disorder characterized by carbohydrate metabolism disturbances and associated with hyperglycemia, marked by high blood sugar levels resulting from abnormalities in insulin secretion, insulin action, or both^{1,19,20}. Diabetes mellitus is distinguished by elevated glucose levels due to reduced insulin secretion by pancreatic beta cells. It is divided into two types: type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM)^{21,22}. According to research by Li *et al.* the International Diabetes Federation predicts a 50% increase in global diabetes cases by 2030 from 366 million cases in 2011, driven by aging populations, rising obesity rates due to unhealthy lifestyles, and increased life expectancy¹⁹. Egan *et al.* in their study citing the World Health Organization (WHO) Global Report, state that diabetes-related mortality rates are alarmingly high, with 3.8 million deaths recorded in 2014, and 43% of these deaths occurring in individuals under 70 years of age²³.

Traditional treatment of diabetes mellitus can involve utilizing plants known for their antidiabetic effects^{24,25}. The use of traditional medicine is a generational heritage passed down from ancestors,

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and herbal remedies are known to have lower side effects compared to chemical drugs^{26,27}. There are over 400 plant species proven to exhibit hypoglycemic activity due to their bioactive components such as polysaccharides, proteins, flavonoids, alkaloids, steroids, and terpenoids, which contribute to their antidiabetic efficacy^{28,29}.

Based on the above considerations, it is crucial to identify the types of medicinal plants utilized by communities, and one way to achieve this is through inventorying plants with medicinal properties^{30,31}. Furthermore, plant inventory involves gathering information about habitat, distribution, population, and types of plants in specific regions. Activities conducted during inventorying include field surveys, species identification, collection of herbarium samples, and data analysis to understand patterns of plant distribution and diversity in a geographic area. The objective is to record, archive, protect, research, and manage these plants collectively for communal benefit^{32,33}.

Based on the above discussion, it is deemed necessary to conduct research on medicinal plants used for diabetes mellitus among the Dayak tribes of Bidayuh Kerambay, Dayak Golik, and Dayak Sinangkan't in the districts of Sekayam, Beduai, and Entikong, Sanggau Regency, West Kalimantan, Indonesia. Specifically, the objective of this study is to inventory and describe the utilization of medicinal plants by the Dayak tribes of Bidayuh Kerambay, Dayak Golik, and Dayak Sinangkan't in these districts of Sanggau Regency, West Kalimantan, Indonesia.

MATERIALS AND METHODS

This research was conducted in the districts of Sekayam, Beduai, and Entikong, Sanggau Regency, West Kalimantan, Indonesia. These three districts were chosen due to their predominance of the Dayak Bidayuh Kerambay, Dayak Golik, and Dayak Sinangkan't ethnic groups.

The method employed in this research is qualitative descriptive, aiming to provide a detailed depiction of a phenomenon or condition observed within its natural context. The objective is to thoroughly describe the characteristics, nature, or qualities of an object or event, without attempting to test hypotheses or make statistical generalizations^{27,34}. Data collection utilized triangulation, combining interview, observation, and documentation techniques^{27,35,36}. Informants were selected using purposive sampling, criteria being traditional healers who have utilized plants as medicine, particularly in treating diabetes mellitus. A total of seven informants were chosen, representing midwives, customary leaders, and traditional healers from the Dayak Bidayuh Kerambay, Dayak Golik, and Dayak Sinangkan't tribes.

RESULTS AND DISCUSSION

Diabetes mellitus is a disease characterized by carbohydrate metabolism disorders marked by hyperglycemia. It is a chronic condition caused by elevated blood sugar levels due to disturbances in carbohydrate, fat, and protein metabolism resulting from insulin deficiency or the body's inability to use insulin effectively. Untreated diabetes mellitus can affect various organs such as the heart, blood vessels, kidneys, nerves, and eyes of the affected individual. This disease can be attributed to unhealthy lifestyles, lack of physical activity, and obesity, which hinder the sensitivity of insulin secretion in the body^{1,19}. According to research by Stojanović *et al.*, diabetes mellitus is divided into two types: type 1 diabetes mellitus and type 2 diabetes mellitus. Type 1 diabetes mellitus is caused by damage to the pancreatic cells, resulting in a reduced amount of insulin secretion or the pancreas' inability to produce insulin. On the other hand, type 2 diabetes mellitus occurs when the body develops resistance to the insulin produced, rendering the insulin ineffective. In type 2 diabetes, the pancreas continues to secrete insulin in larger amounts to compensate for the high blood sugar levels, eventually leading to insufficient insulin secretion in the long term²².

Both conditions result in uncontrolled blood sugar levels and can cause complications in various organs of the body^{20,22}.

Diabetes mellitus cannot be cured outright; rather, patients must continue to consume medications that can lower blood sugar levels or optimize insulin function within the body. According to research by Ummayya *et al.*, the cost of treatment and management of diabetes mellitus in Indonesia is quite expensive. Furthermore, many patients discontinue treatment due to the long-term side effects of medication on other organs. In light of these issues, communities seek alternative treatments that are more affordable and safer for long-term consumption³⁷. One such alternative treatment utilized by the community involves natural ingredients readily available in the surrounding environment. The Dayak tribe in West Kalimantan, Indonesia, is known for their traditional medicinal practices passed down through generations, using plants with medicinal properties for treating diabetes mellitus^{17,18}. Specifically, the findings of this research indicate, based on interviews with informants, that there are 15 types of plants identified as potential treatments for diabetes mellitus. The types of plants used by the Kerambay Dayak tribe include cutleaf groundcherry, billygoat weed, turmeric, cat's whiskers plant, ginger, betel, *simpur*, mangosteen, dayak onion, and white turmeric; the Golik Dayak tribe: cat's whiskers plant, bay leaf, tropical pitcher plants, pea eggplant, *kelakai*, cutleaf groundcherry, and turmeric; and the Sinangkan't Dayak tribe: turmeric, cat's whiskers plant, betel, and longevity spinach. Moreover, the plant parts used in treatment vary among the different types (Table 1), and the methods of processing these plants also vary (Table 2).

Based on the literature study of 15 plant species listed in Tables 1 and 2, it is known that all of these plants have been laboratory-tested and proven to contain phytochemical compounds with anti-diabetic activity. The use of medicinal plants to manage diabetes mellitus is recommended due to their availability, low processing costs, and long-term safety for consumption compared to chemical medications.

The leaves and roots of the cutleaf groundcherry plant (*Physalis*

Table 1. Types of Medicinal Plants for Diabetes Mellitus by the Dayak Bidayuh Kerambay, Dayak Golik, and Dayak Sinangkan't Communities in the Districts of Sekayam, Beduai, and Entikong, Sanggau Regency, West Kalimantan, Indonesia.

No	Tribe	Common Names	Plant Parts Used
1		Cutleaf groundcherry	Leaves and roots
2		Billygoat weed	Leaves
3		Turmeric	Rhizome
4		Cat's whiskers plant	All parts
5	Dayak Kerambay	Ginger	Rhizome
6		Betel	Leaves
7		<i>Simpur</i>	Leaves
8		Mangosteen	Fruit peel
9		Dayak onion	Rhizome
10		White turmeric	Rhizome
11		Cat's whiskers plant	All parts
12		Bay leaf	Leaves
13	Dayak Golik	Tropical pitcher plants	Roots
14		Pea eggplant	Fruit
15		<i>Kelakai</i>	Leaves
16		Cutleaf groundcherry	Roots and leaves
17		Turmeric	Rhizome
18		Turmeric	Rhizome
19	Dayak Sinangkan't	Cat's whiskers plant	All parts
20		Betel	Leaves
21		Longevity spinach	Leaves

Table 2. Methods of Processing Medicinal Plants for Diabetes Mellitus by the Dayak Bidayuh Kerambay, Dayak Golik, and Dayak Sinangkan't Communities in the Districts of Sekayam, Beduai, and Entikong, Sanggau Regency, West Kalimantan, Indonesia.

No	Local Names	Scientific Names	Processing Methods
1	Cutleaf groundcherry	<i>Physalis angulata</i> L.	Take approximately 500 grams of cutleaf groundcherry plants, wash the leaves and roots thoroughly, then cut them into pieces. Boil them in 500-1000 ml of water for 3 minutes, strain, and drink the decoction twice a day.
2	Billygoat weed	<i>Ageratum conyzoides</i> L.	Take approximately 300 grams of young leaves of billygoat weed, then boil them in 500 ml of water until wilted. Drink the decoction once a day in the evening before bedtime. The leaves of billygoat weed can also be pounded and applied to diabetic wounds.
3	Turmeric	<i>Curcuma domestica</i> Valetton	Take approximately 500 grams of turmeric, clean and slice it finely. Boil it with 500 ml of water until it boils, then drink the decoction once a day in the evening before bedtime. Turmeric can also be grated, and approximately 100 ml of its juice can be consumed.
4	Cat whiskers plant	<i>Orthosiphon stamineus</i> B.	Take approximately 300 grams of cat's whiskers plant, wash it thoroughly, then finely slice it and brew it with 500 ml of hot water. Afterward, drink the decoction once a day in the evening before bedtime.
5	Ginger	<i>Zingiber officinale</i> Rosc.	Take approximately 150 grams of the plant, clean it thoroughly, then finely slice it and boil it in 500-1000 ml of water until it boils. Optionally, you can add some palm sugar to taste. Drink the decoction once a day in the evening before bedtime.
6	Betel	<i>Piper betle</i> L.	Take 10 fresh betel leaves, wash them thoroughly, then boil them in 500 ml of water until it boils. Drink the decoction twice a day, in the morning after meals and in the evening before bedtime.
7	Simpur	<i>Dillenia suffruticosa</i> (Griff.) Martelli	Take 5-10 young <i>simpur</i> leaves, wash them thoroughly, then boil them in 500 ml of water until they are soft. Afterward, consume them.
8	Mangosteen	<i>Garcinia mangostana</i> L.	Take approximately 500 grams of mangosteen peel, then sun-dry it for 3-5 days until it is dried. Afterward, boil it in 500-1000 ml of water until it boils. Drink the decoction twice a day, in the morning and evening.
9	Dayak onion	<i>Eleutherine palmifolia</i> (L.) Merr	Take 300 grams of dayak onion tubers, wash them thoroughly, then finely slice and boil them in 500 ml of water until boiling. Subsequently, consume the decoction once daily in the evening. The preparation may also incorporate thinly sliced ginger and an appropriate amount of brown sugar.
10	White turmeric	<i>Curcuma zedoaria</i> (Christm.) Roscoe	Take approximately 500 grams of white turmeric, clean it thoroughly, then finely slice and boil it with 500 ml of water until boiling. Subsequently, drink the decoction once daily in the evening before bedtime. White turmeric can also be grated, and approximately 100 ml of its juice can be extracted and consumed.
11	Bay leaf	<i>Syzygium polyanthum</i> (Wight) Walp.	Take 200 grams of bay leaves, wash them thoroughly, then boil them with 500 ml of water. Drink the decoction twice daily, in the morning and in the afternoon.
12	Tropical pitcher plants	<i>Nepenthes</i> sp.	Take 200 grams of tropical pitcher plant roots, wash them thoroughly, then boil them with 500 ml of water. Afterward, drink the decoction once daily, either in the morning or evening.
13	Pea eggplant	<i>Solanum torvum</i> Swartz	Take as much as needed of pea eggplant fruit, wash them thoroughly, and serve them as a side dish for meals.
14	Kelakai	<i>Stenochlaena palustris</i> (Burm.f.) Bedd.	Take approximately 300 grams of <i>kelakai</i> leaves, wash them thoroughly, and boil them with 500 ml of water. Then, drink the decoction twice a day, in the morning and evening, after meals.
15	Longevity spinach	<i>Gynura procumbens</i> (Lour.) Merr.	Take 10 leaves of longevity spinach plant, wash them thoroughly, and boil them with 500 ml of water until boiling. Drink the decoction once a day, in the morning and evening, after meals.

angulata L.) have been reported to serve as an alternative treatment for diabetes mellitus. This is due to the presence of compounds in cutleaf groundcherry that exhibit anti-diabetic activity, including vitamin C, quercetin, and physagulin F. Quercetin, a flavonoid, can lower blood pressure and synergize effectively with vitamin C, while physagulin F, a steroid compound, enhances insulin sensitivity. A recommended consumption dosage for cutleaf groundcherry as an anti-diabetic treatment is 150 mg/kg body weight^{38,39}.

The leaf part of billygoat weed (*Ageratum conyzoides* L.) is known to lower blood glucose levels in individuals with diabetes mellitus. In line with its medicinal properties for lowering blood sugar, billygoat weed contains alkaloids, cardiac glycosides, flavonoids, saponins, tannins, and triterpenes. Alkaloids in billygoat weed can enhance glucose consumption in the body, while flavonoids, cardiac glycosides, and saponins work to improve insulin secretion sensitivity. Tannins help reduce carbohydrate absorption in the body, thereby maintaining controlled blood glucose levels. Moreover, billygoat weed also contains triterpenes, which have anti-diabetic activity by stimulating and stabilizing insulin hormones. An effective dosage of billygoat weed for use as an anti-diabetic treatment is recommended at 200 mg/kg body weight^{40,41}.

The entire plant of cat whiskers plant (*Orthosiphon stamineus* B.) is also used by the Dayak people in treating diabetes. This plant contains several compounds with antidiabetic activities such as flavonoids (beta-caryophyllene, alpha-humulene, caryophyllene-epoxide), triterpenes, and saponins that can reduce blood sugar levels and enhance the effectiveness of insulin hormone. Additionally, cat whiskers plant also contain phenolic and terpenoid compounds that inhibit the α -glucosidase enzyme, thereby preventing the increase of blood sugar levels. Phenolic compounds also inhibit the digestion of starch in the body. Cat whiskers plant should be consumed as an antidiabetic treatment at a sufficient dosage of 1.25 g/kg body weight, which has been reported to be as effective as metformin when administered for 28 days in diabetic patients^{44,45}.

Ginger rhizome (*Zingiber officinale* Rosc.) is widely used as a culinary spice and traditional herbal remedy. One of its benefits is its use as an antidiabetic medicine due to its ability to lower blood sugar levels. Ginger rhizome contains compounds that can minimize blood sugar levels and exhibit antidiabetic activity. These compounds include gingerol and phenolic compound known as shogaol. Gingerol is

reported to manage diabetes by enhancing glucose uptake into muscles and increasing insulin sensitivity, while shogaol can reduce the amount of sugar in the blood, thereby stabilizing blood sugar levels. Administration of ginger at 1000 mg/day has been reported to reduce blood sugar levels in diabetic patients^{46,47}.

Betel leaf (*Piper betle* L.) is also known to have benefits in managing diabetes mellitus. These benefits are based on the phytochemical content of betel leaves that exhibit antidiabetic activity. Among the compounds found in betel leaves are subclasses of flavonoids such as flavones and anthocyanins, terpenoids (1,8-cineole, camphene, cadinene, caryophyllene, pinene, limonene, chavicol, carvacrol, allyl pyrocatechol, chavibetol, eugenol, and safrole), alkaloids, steroids, and glycosides. Flavonoid compounds cause cells in the body to respond effectively to insulin, thereby improving glucose uptake efficiency. Additionally, flavonoids in betel leaves can inhibit α -glucosidase, preventing carbohydrates from breaking down into glucose and preserving pancreatic cells. Terpenoid compounds help stabilize insulin secretion in the body, while alkaloids, steroids, and glycosides play roles in regulating glucose metabolism. The use of 20 g/kg body weight of betel leaf as an antidiabetic medicine has been reported to reduce blood sugar levels by up to 38% without causing harmful side effects^{48,49}.

Simpur leaves (*Dillenia suffruticosa* (Griff.) Martelli) are known for their potential in managing diabetes due to their ability to lower blood sugar levels. This is attributed to the presence of compounds such as flavonoids, saponins, tannins, alkaloids, triterpenoids, and steroids, which enhance insulin activity and regulate blood sugar levels. Saponins and tannins in *simpur* are reported to increase the sensitivity of pancreatic cells to secrete insulin. Additionally, these compounds provide antioxidant effects that aid in repairing cell damage caused by elevated blood sugar levels. *Simpur* leaves can be used as an antidiabetic treatment at a dosage of 600 mg/kg body weight^{50,51}.

The known benefits of mangosteen fruit peel (*Garcinia mangostana* L.) have been scientifically tested in laboratory settings to act as an antidiabetic remedy. This is attributed to several active compounds found in mangosteen peel that exhibit antidiabetic activity. Among these compounds are polyphenols such as flavonoids, phenols, and xanthenes. Flavonoids in mangosteen fruit peel act as inhibitors of α -amylase enzymes, preventing disaccharides from being broken down into glucose and helping to control blood sugar levels. Additionally, phenolic compounds can address insulin resistance in the body, enhancing the effectiveness of insulin in managing high blood sugar levels. Mangosteen fruit peel also contains a unique compound known as xanthone, specifically α -mangosteen, which serves as a potent antioxidant and protects pancreatic cells from damage in individuals with diabetes mellitus. Moreover, xanthenes help stabilize insulin secretion to manage elevated blood sugar levels effectively. Consumption of 600 mg/kg body weight has been shown to effectively lower blood sugar levels in individuals with diabetes mellitus^{52,53}.

The rhizome of the dayak onion (*Eleutherine palmifolia* (L.) Merr) is known to be used as a treatment for diabetes mellitus by the Dayak people. This usage is based on the presence of compounds believed to be beneficial in controlling blood sugar levels, supported by research such as Hairani *et al.*, which states that dayak onion contains active compounds with antidiabetic and antioxidant properties for individuals with diabetes mellitus, including phenolics, terpenoids, flavonoids, and carotenoids primarily found in its bulbs. Specifically, dayak onion contains active compounds such as hongconin, dihydroeleutherin, and eleutherinone, which help protect cells from damage due to high blood sugar levels. Compounds like isoeleutherol, eleutherol, eleutherinoside A, and eleuthoside B act as inhibitors of β -glucosidase enzyme activity, which breaks down cellulose into glucose, thereby helping to control blood sugar levels. Consumption of 500 mg/kg body weight has been

reported to effectively and significantly lower blood sugar levels in the body⁵⁴.

White turmeric rhizome (*Curcuma zedoaria* (Christm.) Roscoe) has been recognized as one of the treatments and therapies for diabetes mellitus. This benefit is derived from the phytochemical compounds present in the white turmeric rhizome, which have the ability to help reduce blood sugar levels. White turmeric contains flavonoids such as luteolin and luteolin 7-O-glucoside, which can lower blood sugar levels. It also contains α -pinene and curcumin, which are believed to protect β cells in the pancreas, allowing for proper insulin secretion in individuals with diabetes mellitus. Consumption of 400 mg/kg body weight of white turmeric is known to be therapeutic in the treatment of diabetes mellitus by reducing and controlling blood sugar levels in the body^{55,56}.

Bay leaves (*Syzygium polyanthum* (Wight) Walp.) are known to be used in the treatment of diabetes due to several compounds that can address this condition. These compounds include derivatives of benzoic acid, specifically 4-hydroxy-3-methoxybenzoic acid and 4-hydroxy-3,5-dimethoxybenzoic acid, catechin compounds such as epigallocatechin-3 gallate, and the flavonoid myricitrin, which acts as an inhibitor of α -glucosidase enzymes, thereby reducing blood sugar levels. Additionally, aliphatic terpenoid compounds like squalene contribute to lowering blood sugar and increasing glucose uptake in muscle tissue. Consumption of bay leaves at a dosage of 700 mg/kg body weight is reported to effectively control blood sugar levels^{54,57}.

The study conducted by Nguyen & Vo found that the roots of tropical pitcher plant (*Nepenthes* sp.) contain phytochemicals with antidiabetic activity. These compounds include alkaloids, flavonoids, anthraquinones, terpenoids, tannins, and phlobatannins. Flavonoids, terpenoids, and tannins are reported to lower blood glucose levels and increase the sensitivity of insulin secretion. Anthraquinone compounds also inhibit the action of amylase and glucosidase enzymes, thereby controlling the breakdown of starch into glucose. The recommended dosage of tropical pitcher plant root for antidiabetic treatment is 500 mg/kg body weight⁵⁸.

The pea eggplant (*Solanum torvum* Swartz) is reported to have efficacy as a treatment for diabetes mellitus. This is supported by phytochemical compounds found in the fruit of pea eggplant such as phenols, tannins, flavonoids, alkaloids, glycosides, and vitamin C. Phenolic compounds, tannins, and flavonoids in pea eggplant are known to lower blood glucose levels and maximize insulin hormone sensitivity, thereby effectively controlling blood sugar levels. Additionally, there are glycoside compounds and vitamin C present. Glycosides play a role in reducing the body's activity in absorbing glucose, increasing the secretion of insulin hormones in the body, and maximizing the absorption of glucose from the blood into muscle tissues. Vitamin C in wild pea eggplant enhances the performance of glycosides, optimizing the anti-diabetic activity performed. Consumption of pea eggplant tends to be unlimited as it does not produce harmful effects on the body^{59,60}.

The *kelakai* leaves (*Stenochlaena palustris* (Burm.f.) Bedd.) has anti-hyperglycemic activity, meaning it can lower blood sugar levels. This is due to the presence of phytochemical compounds such as phenols, flavonoids, and tannins in *kelakai* leaves. *Kelakai* leaves are reported to contain abundant stigmasteryl, kaempferol, and flavonol glycosides, which have been found effective in reducing blood sugar levels in diabetes mellitus patients. As an anti-diabetic treatment, *kelakai* plant is recommended to be consumed at a dose of 500 mg/kg body weight, considered most effective in managing blood sugar^{61,62}.

According to research conducted by Le *et al.*, longevity spinach (*Gynura procumbens* (Lour.) Merr.) can be one of the treatments for diabetes mellitus. The leaves of *Gynura procumbens* (Lour.) Merr. contain active compounds such as alkaloids, flavonoids, saponins, and phenols which

exhibit anti-diabetic activity and serve as antioxidants. Specifically, longevity spinach plant contains chlorogenic acid, rutin, astragaloside, and kaempferol-3-O-rutinoside which have been reported to act as anti-diabetic agents and regulate blood glucose levels. It is reported that consuming longevity spinach at 100 g/kg body weight can manage blood sugar issues and reduce blood glucose levels in individuals with diabetes mellitus⁶³.

SUMMARY

There are 15 types of plants used by the Dayak tribe community to manage diabetes mellitus. Among these 15 types of plants, the parts utilized vary, while the method of preparation remains the same, which is boiling.

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