A Review of Medicinal Plants and Daily Foods used in Southeast Asia Possessing Antidiabetic Activity

Wan Nadilah Adibah Wan Ahmad[a,*], Nor Hasima Mahmod[a,b] and Abdul Manaf Ali[a,b]

[a] Institute of Agricultural Production and Food Innovation (AGROPOLIS),
Universiti Sultan Zainal Abidin (UniSZA), Besut Campus, 22200, Besut,
Terengganu Darul Iman, MALAYSIA.

[b] Faculty of Bioresources and Food Industry,
Universiti Sultan Zainal Abidin (UniSZA), Besut Campus, 22200, Besut,
Terengganu Darul Iman, MALAYSIA.

***Corresponding author: wnadilahahmad@unisza.edu.my**

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ABSTRACT

According to the recent estimates by the World Health Organization (WHO), 422 million adults aged over 18 years were living with diabetes in 2014 globally. Surprising, about 1.6 million deaths was reported cause directed by diabetes in 2016. In Southeast Asia alone, 96 million people have diabetes, and this is predicted to increase. The incidence of diabetes is worryingly increasing especially in developing countries. Numerous synthetic drugs have been discovered to control this disease, but these drugs can lead to negative side effects. Therefore, people are looking for natural remedies to combat the disease. The objective of this review is to study of the medicinal plants and daily foods that have been used to treat diabetes. Instead of common traditional medicinal plants such as *Andrographis paniculata, Averrhoa bilimbi, Camellia sinensis, Cosmos caudatus* Kunth*, Leucaena leucocephala, Momordica charantia, Ocimum sanctum, Orthosiphon stamineus, Panax ginseng* and *Pereskia bleo* and; daily foods ingredients like fenugreek, garlic, ginger, onion and turmeric possess significant positive effects on diabetic patients. Antioxidants, for instance andrographolide, flavonoids glycosides like epicatechin, quercetin, catechin, myricetin, epigallocatechin gallate, polysaccharide compound galactomannan, saponin, gingerol, allicin, euganol and curcuma, dietary fibers and some minerals such as magnesium as well as amino acid such as 4-hydroxyisoleucine were found to be responsible for this effect. Although some responsible compounds are known, the mechanisms involved are not yet fully explored. Thus, further research on the mechanism, effective dosage and toxicity of the particular medicinal plants need to be comprehensively studied before they can be marketed as nutraceutical products.

Keywords: Diabetes mellitus, natural remedies, medicinal plants

INTRODUCTION

According to the International Diabetes Federation (IDF) (2011), about 366 million people worldwide, had diabetes mellitus (DM) and this number is expected to rise to 522 million by 2030. The present trend indicated that more than 60% of the world's diabetic population is from Asia (Yang *et al.,* 2010). In Malaysia, an alarming 3.6 million adults of greater than 18 years old, were estimated to be affected by diabetes (The Star, 2013). National Health and Morbidity Survey indicated that the prevalence of diabetes among adults has increased from 11.6% in 2006 to 15.2% in 2011. Each year, the number of diabetic patients is a serious concern because statistically, one out of seven adults in Malaysia will suffer from diabetes.

Two forms of DM are recognized, namely Type 1 and Type 2 DM. Type 1 insulin-dependent diabetes mellitus (T1DM), which accounted for 5 - 10% of the total number of diabetes patients, is a condition in which the body fail to produce insulin, mostly occurring in children and young adults. People with T1DM must take insulin injection daily in order to survive. Type 2 non-insulin dependent diabetes mellitus (T2DM) is the most common type of diabetes, accounting for 90 - 95% of cases. This type of DM occurs when the body does not produce enough insulin or is unable to use the insulin. The main cause of T2DM is diet mismanagement, usually involving high intakes of sugar (Li *et al.,* 2008). Therefore, people with T2DM can sometimes manage their condition with lifestyle measures alone, but oral drugs are often required, and less frequently insulin, in order to achieve good metabolic control (Esposito *et al.,* 2010; Asif, 2014).

Despite the vast understanding of its epidemiology, there are no effective therapies to cure DM and a define solution for its prevention and causes are still not forthcoming (Zhang *et al.,* 2008; WHO, 2016). Acarbose, miglitol, voglibose and nateglinide are drugs used alone or together with insulin to treat this disease. Unfortunately, these medications can cause side effects and high secondary failure rates (Sugihara *et al.,* 2014; DiNicolantonio *et al.,* 2015). Furthermore, due to their high costs of acarbose 50 mg (USD 0.36 – USD 1.33), miglitol 50 mg (USD 0.38 – USD 1.26), **v**oglibose 0.3 mg (USD 0.54 – USD 0.70) and nateglinide 120 mg (USD 0.37 – USD 0.75 per pill or unit) (My PharmacyChecker, 2018), these drugs cannot be afforded by a majority of people living in the rural communities of developing countries such as India (Kokiwar *et al.,* 2010), South Africa (Stokes *et al.,* 2017) and Sub-Saharan Africa (Animaw and Seyoum, 2017). This failure leads to a greater demand for alternative therapies, particularly safer and more effective antidiabetic agents. Many studies have focused on the exploration of herbal remedies as treatment of DM, since this natural method of treatment promises lesser side effects and lower costs than using modern, synthetic drugs (Prihantini *et al.,* 2014; Sulaiman and Ooi, 2014; Shori, 2015; Alam *et al.,* 2017; Wan-Nadilah *et al.,* 2018). Medicinal plants have been proved effective and traditionally used for the treatment of diabetes for thousands of years. Moreover, the importance and uses of medicinal plants are also stated in different religious books (i.e., the Holy Qur'an, the Bible). About 19 medicinal plants and 176 medicinal plants are mentioned in the Holy Qur'an (Urbi *et al.,* 2014) and the Holy Bible (Duke, 2007), respectively. In Southeast Asian country, medicinal plants that are commonly consumed including *Andrographis paniculata* (AP), *Averrhoa bilimbi* (AB), *Camellia sinensis* (CS), *Cosmos caudatus* Kunth (CC), *Leucaena leucocephala* (LL), *Momordica charantia* (MC), *Ocimum sanctum* (OSA), *Orthosiphon stamineus* (OST), *Panax ginseng* (PG) and *Pereskia bleo* (PB), while also commonly included in daily food ingredients are fenugreek, garlic, ginger, onion and turmeric (Paramanick, and Sharma, 2017).

At present, there are numerous of studies conducted on these medicinal plants focusing on the mechanism of action and their efficacy alleviating diabetes. There are also systematic reviews compiling these studies. However, to the best of authors' knowledge there has been orderly review compiling the medicinal plants that are being used in Southeast Asian complementary medicine practice to treat diabetes available. Thus, the main objective of this review is to summarize the studies of the medicinal plants mentioned earlier and to determine the compounds that are responsible for hypoglycemic properties. These medicinal plants are particularly chosen to be reviewed in this article because of their regular consumption and they are easily found.

DIABETES MELLITUS

Symptoms and Genesis

There are several distinctive symptoms that can be associated with diabetes. The symptoms include the increase of thirst and urine volume, repeated infections, and unexplained weight loss (Steven *et al.,* 2010). Excessive thirst occurs when the kidney fails to reabsorb excessive sugar during urine filtration. In order to counteract this problem, the system requires more water to dilute high blood glucose level to turn back to normal. Inefficiency in the metabolism of food intake especially glucose and sugar, as well as a large amount of water excretion will be the main contributors to weight loss (Nongmaithem *et al.,* 2016). The presence of blood glucose in tissue may suppress the immune system in which suppression may result in recurrent infections (Zhao *et al.,* 2018). On the other hand, high blood sugar level helps bacteria grow well. Fatigue is another common symptom for diabetes which may result from body's inefficiency or inability to use glucose as fuel. When glucose could not be used as fuel, fat will be used as an alternative and the utilization of fuel from fat requires greater energy. Excessive eating is another symptom of diabetes. Theoretically, in high sugar condition, the body will try to secrete more insulin. Besides its main function which is to convert glucose into glycogen, insulin also stimulates hunger which leads to excessive food consumption. Another common symptom of diabetes is poor wound healing (Sharp and Clark, 2011). High blood glucose level prevents white blood cells from functioning properly, thus the time take for wound healing is longer than usual (Sharp and Clark, 2011). Drowsiness and coma are also the symptoms of diabetes, but they are common at the severe stage (American Diabetes Association, 2015).

Epidemiology

The number of people with diabetes has risen from 108 million in 1980 to 422 million in 2014 and by 2045, this will rise to 629 million (Diabetes Care, 2014; IDF Diabetes Atlas, 2017). Globally, 9% of adults have diabetes causing an estimated 1.6 million deaths per year worldwide. Southeast Asia is 19% of the total number of people with diabetes in the world. This region had the second highest number of deaths attributable to diabetes of any of the seven IDF regions (IDF Diabetes Atlas, 2017). Southeast Asia consists of eleven countries namely Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste and Vietnam. The prevalence of diabetes mellitus in Southeast Asia countries is summarized in Table 1.

Table 1. Prevalence of diabetes mellitus in Southeast Asia

Country	Prevalence (%)	Study details (Study date, study setting, age group)	Reference
Brunei	12.4	2011, National, >20 years	Brunei National Health and Nutritional Status Survey (2011)
Cambodia	5.9	2016, National, 30-69 years	World Health Organization (2016)
Indonesia	28.4	2006, Urban, 25-64 years	Soewondo *et al.* (2010)
Laos	4.0	2017, National, 20-19 years	International Diabetes Federation (2018)
Malaysia	17.5	2015, National, 18-69 years	Tee and Yap (2017)
Myanmar	6.6	2016, National, 30-69 years	World Health Organization (2016)
Philippines	14.5	2003, National, > 20 years	Morales *et al.* (2008)
Singapore	10.5	2010, National, 18-69 years	Singapore National Health Survey (2010)
Thailand	11.9	2000, Rural, 30-74 years	Cockram (2000)
Timor-Leste	6.9	2017, National, 20-79 years	International Diabetes Federation (2018)
Vietnam	5.6	2015, National, 20-79 years	International Diabetes Federation (2015)

Table 1 shows that the highest diabetes prevalence rate was recorded in Indonesia with appalling 28.4%. There were three studies conducted in different areas of Jakarta, which were in 1982, 1992 and 2010. The studies showed the diabetes prevalence rates tended to increase rapidly, in urban populations, within a short duration (Cockram, 2000; Soewondo *et al.,* 2010) with crude prevalence rates of 1.7%, 5.7% and 28.4%, respectively. It indicated a three to five-fold rise within a decade. However, since age distribution details were lacking, the prevalence rates are difficult to compare with other researches findings.

The prevalence of diabetes among Malaysian residents is equally frightening as it has increased over the decade. The National Survey that was conducted in 1997 shows the prevalence of diabetes exceeded 8% (Cockram, 2000) and increased to 15.2% in 2008 (Mohamud *et al.,* 2011) and 17.5% in 2015 (Tee *et al.,* 2017). While in Singapore, one in nine Singaporean aged 18 to 69 years were affected by diabetes in 2010 (Singapore National Health Survey, 2010). The prevalence of Singaporean with diabetes was similar between the genders. Meanwhile, Indians and Malays consistently had a higher prevalence of diabetes compared to Chinese across the years. Both Malaysia and Singapore demonstrated a very rapid rise within one to three decades. Since the mid-1970s, the chronological studies from Singapore have indicated an approximate doubling in prevalence during each decade.

On the other hand, the diabetes prevalence rates in Cambodia, Laos, Myanmar, Timor-Leste and Vietnam are still relatively small (Table 1). It may be attributed to their degree of economic development and epidemiological transition of these countries which are still in the beginning stages and it may be expected their diabetes prevalence rates remain relatively low (WHO, 2016).

Generally, the rise of the percentage rates of diabetes mellitus throughout this region may be related to the lifestyle, wealth, urbanization and mechanization. For example, routine and physical activity especially in younger communities, related to increased obesity and particularly central obesity, would contribute to T1DM (Monaghan *et al.,* 2015). There is a low percentage of DM in traditional communities, but it increases in society with urbanization and modernization. This effect has been recorded by Cockram (2000), which showed in excess of 30% of the adult population in the urban areas were affected by diabetes. One of the risks is a combination of genetic predisposition and changes of lifestyle.

Overall, there is heterogeneity of prevalence of this disease among the countries. Comparison and interpretation of prevalence studies are sometimes made complicated by dissimilarity in methodology, diagnostic criteria, or age of subjects studied. The rate of recurrence for diabetes study needs standard research in order to get a rather significant evaluation and understanding about the pattern of the disease. However, the lack is not our focus in this review.

Risk factors

Type 1 (T1DM) and type 2 diabetes mellitus (T2DM) can occur at all age stages nowadays. The environments like geography, ethnic, changing nutrition, physical inactivity, drugs and toxic agents, obesity and viral infection are parts of the occurrence factors of T1DM (González *et al.,* 2017). The increase in diabetes is dramatically correlated with increased obesity, especially central obesity in all populations (Bhupathiraju and Hu, 2016). There is higher occurrence of this disease recorded during winter and autumn months which made seasonality becomes a crucial factor. The season can enhance other environmental factors such as viral infection which lead to the development of T1DM. Interestingly, Frederiksen et al. (2013) studied about the short duration of breast-feeding during infancy contributed to the development of T1DM. This is related with the ingredient and antibodies of cow's milk given to babies especially to recent-onset T1DM (Miralles *et al.,* 2018). The presence of a higher amount of protein in cow's milk makes permeability of neonatal guts with protein thus makes bovine albumin increase the antibodies which cross react with protein in the β-cell membrane.

The genetic factor is one of the factors that contribute to both T1DM and T2DM (Olokoba *et al.,* 2012). It is a more crucial factor for T2DM compared to T1DM. Children are more exposed to diabetes if maternal age is older (Cardwell *et al.,* 2010). Likewise, age, sex and socioeconomic status also can influence diabetes prevalence (Kautzky-Willer *et al.,* 2016). Women have a high risk of diabetes due to the high amount of obese women nowadays. Older people (>20 years old) have a high risk to get diabetes. Urban population with particularly high in socioeconomic status has a high potential occurrence of diabetes (Corsi and Subramaniam, 2012).

Sedentary habits, sleeping during day time, eating excessively particularly sweet and fatty substance also lead to the development of diabetes (Yau and Potenza, 2013).

MEDICINAL PLANTS AND DAILY FOODS WITH ANTIDIABETIC PROPERTIES

The use of medicinal plants and daily foods as a remedy for diabetes is common in many societies (Khan and Yadava, 2010; Loh and Hadira, 2011; Patel *et al.,* 2012). The users include both normal healthy individuals and those suffering from the disease, as preventive and curative measures, respectively. Table 2 summarizes an extensive use of ten medicinal plants and five daily foods that have been evaluated in various *in vivo* model, mostly using alloxan- and/or streptozotocin- (STZ) induced diabetic animals which are the most frequently used in animal diabetes models worldwide. In addition, also reviewed here is *in vitro* models that could possibly explain some of their mechanism of action such as inhibitory effects against either α-glucosidase or α-amylase enzymes. Moreover, plant is able to increase the expression of the glucose transporter GLUT4, which in turn increases glucose uptake into muscles and adipose tissues. These *in vitro* experiments are often designed to 'reflect' the mechanism of existing drugs used in diabetes management. The exact identification of the constituent(s) responsible of *in vitro* model should be further established to provide a better understanding of the plant's therapeutic potential. This is notwithstanding the fact that the bioactive constituents could be exerting the effect individually or synergistically, as is the case in most plant extracts.

Table 2. Medicinal plants used in the management of diabetes in Southeast Asia countries.

Plant name	Family	Malaysian common name	Experimental evidence for its use in diabetes management	Other medicinal uses	Plants part (s) used	Traditional preparation method	Identified active constituent (s) for diabetes
Andrographis paniculata	Acanthaceae	Hempedu bumi	AP extract contain andrographolide effectively showed hypoglycemic effect by (a) inhibiting of α-glycosidase and α-amylase activity (Subramanian and Asmawi, 2006; Subramaniam *et al.,* 2008; Chao *et al.,* 2010; Jayakumar *et al.,* 2013); (b) increasing insulin signal and thus stimulating glucose uptake by peripheral tissues (Subramanian *et al.,* 2008); (c) controlling abnormal lipid metabolism; (d) scavenging free radicals resulting in decreased number of efficient plasma membrane receptors or transporter proteins necessary to uptake glucose from the blood stream (Williams *et al.,* 2014). AP ethanol extract efficiently lowered blood glucose level in human (Subramanian and Asmawi, 2006; Subramanian *et al.,* 2008). Andrographolide at 50 mg/kg effectively decreased blood glucose level, stimulated GLUT4 translocation (Zhang *et al.,* 2013), and improved diabetic rat's islet and beta cell functions (Nugroho *et al.,* 2012). Glucose induced hyperglycemia has been prevented by water extracts of AP in non-diabetic rats without affecting epinephrine-induced hyperglycemia (Hossain *et al.,* 2014).	Hypertension, anticancer, antidiarrheal, anti-hepatitis, anti-HIV, anti-inflammatory, antimicrobial, antimalarial, cardiovascular, cytotoxic, hepatoprotective, immune-stimulatory, sexual dysfunctions.	Whole plant, Leaves, Aerial parts, Stems, Roots	Decoction, Maceration	Andrographolide, is the major constituent of this medicinal plant which is responsible for the bitter taste is responsible for this anti-hyperglycemic effect (Yu *et al.,* 2008; Zhang *et al.,* 2013; Nugroho *et al.,* 2012). Another bioactive compound, namely 14-deoxy-11, 12-didehydroandrographolide (Hossain *et al.,* 2014).

Averrhoa bilimbi	Oxalidaceae	Belimbing buluh, belimbing asam	Previous studies reported the reduction of blood glucose levels and food intake in diabetic rats given fruit and leaf extracts of AB (Tan *et al.,* 1999; Pushparaj *et al.,* 2000; Pushparaj, 2005). Further study by Sharangi (2009), showed the presence of significant amounts of nicotinic acid (NA) and magnesium (Mg) that had a synergistic effect on glucose tolerance in animal models of T1DM and T2DM. However, no in vitro studies have been conducted to investigate the α-glucosidase inhibition activity of AB.	Hypotriglyceridaemia, anti-lipid peroxidative, anti-atherogenic, antibacterial, antiscorbutic, anti-inflammation, hypertension, anti-obesity, astringent, fever, itches, fever, boils, skin eruptions, bites of poisonous creatures, rheumatism, cough, cold, mumps, syphilis, treat pimples.	Fruits, leaves, flowers	Juicy fruits, decoction, and infusion of leaves and flowers.	Phenolic compounds and quercetin (Pushparaj, 2005; Sharangi, 2009).
Camellia sinensis	Theaceae	Tea	It has been scientifically proven to possess antidiabetic property in both T1DM (Sharangi, 2009) and T2DM (Sharangi, 2009; Xia *et al.,* 2018). Iso *et al.* (2006) recommends using more than 6 cups a day of CS can reduce the chances of diabetes rather than those who drink a cup each week.	Anti-aging, anti-Alzheimer, anti-Parkinson, anticancer, anti-stroke, cardiovascular effect, skin disorders.	Leaves	Infusion	The most active is epigallocatechin-3-gallate (EGCG) (Sharangi, 2009; Xia *et al.,* 2018). Others are epicatechin gallate (ECG), epicatechin (EC) and epigallocatechin (EGC).
Cosmos caudatus	Asteraceae	Ulam raja	The previous study reported that CC extract was significantly potent than positive control, quercetin in α-glucosidase inhibitory activity (Wan-Nadilah *et al.,* 2018). Also, CC extract-treated rats showed a significant reduction in plasma blood glucose as compared to the control rats after one month of CC extract supplementation (Perumal *et al.,* 2014).	Antioxidant, anti-hypertensive, anti-inflammatory, anti-hyperlipidemic, antimicrobial, anti-fungal, anti- mutagenic, anti-osteoporotic activities.	Whole plant, Leaves, Roots	Fresh leaves, Infusion roots	Favonoids glycosides (Wan-Nadilah *et al.,* 2018).

Leucaena leucocephala	Fabaceae	Petai belalang	The seed extract from LL inhibits elevated blood glucose and lipids levels but increases the number of pancreatic islets (Syamsudin and Simanjuntak, 2006; Syamsudin *et al.,* 2010). Moreover, the seed extract of LL can be used for the treatment of DM without affecting hepatic function, but there is an impact on renal function (Chowtivannakul *et al.,* 2016).	Antimicrobial, anthelmintic, antibacterial, anti-proliferative, anticancer, anti-inflammatory, antioxidant, antitumor, antihistaminic, nematicide, pesticide, anti-androgenic, hypocholesterolemic, hepatoprotective properties.	Leaf, Seed	Infusion of leaves, seeds	Glycosides with monosaccharide galactose clusters and other saccharides. The most active compound for antidiabetic properties is galactomannans. (Syamsudin *et al.,* 2010).
Momordica charantia	Cucurbitaceae	Peria katak, bitter melon	MC ethanolic extracts effectively lowered blood glucose level in Alloxan induced rabbits. There was a significantly decrease of glucose blood level in high dose (1.5g/kg) compared to low and median dose with 0.5g/kg and 1g/kg, respectively using LSD test. This is comparable to the effect of metformin (Yakaiah *et al.*, 2013). Meanwhile charantin isolated from fruits of MC was tested for its hypoglycemic activity. In fasting rabbits, it gradually lowered blood sugar within 1-4 hours and recovered slowly to the initial level. Charantin was found to be more potent than tolbutamide (Ahmed *et al.,* 2017).	Antibacterial, antiviral, antitumor, antioxidant, immunomodulatory, anti-diarrheal, anthelmintic, antimutagenic, antiulcer, antilipolytic, antifertility, hepatoprotective, anticancer, anti-inflammatory cardiovascular effects, anti-malaria activities.	Fruits, Seeds, Leaves, Roots	Juicy fruit, infusion and decoction of leaves, roots	Cucurbitane triterpenoids, momocharin, momordicin (Yakaiah *et al.,* 2013; Ahmed *et al.,* 2017).

Ocimum sanctum	Lamiaceae	Selasih, Tulsi, Holy basil	The leaf extracts of OS were reduced blood glucose level by increasing the insulin secretion from isolated islets, perfused pancreas and clonal pancreatic β–cells (Antora *et al.,* 2017). The leaf extract of OS aqueous shows the significant reduction in blood sugar level in both normal and alloxan induced diabetic rats (Nim *et al.,* 2013; Mousavi *et al.,* 2016).	Antibacterial, antiviral, antimalarial, anthelmintic, antidiarrheal, analgesic, antipyretic, anti-inflammatory, anti-allergic, antihypertensive, cardio protective, central nervous system (CNS) depressant, memory enhancer, anti-hypercholesterolemia, hepatoprotective, anti-asthmatic, anti-thyroidic, antioxidant, anticancer, chemo preventive, radio protective, immunomodulatory, antifertility, antiulcer, anti-arthritic, anti-stress, anti-cataract, anti-leucodermal, anticoagulant activities.	Leaves	Infusion and decoction, of leaves	Eugenol has the highest potentials (Nim *et al.,* 2013; Mousavi *et al.,* 2016).
Orthosiphon stamineus	Lamiaceae	Misai kucing, Java tea	In an oral glucose tolerance test, 0.2 to 1.0g/kg water extract of OS significantly lowered plasma glucose concentration for both normal and diabetic rats. At the dosage of 1.0g/kg, OS showed similar effect with glibenclamide at 5mg/kg. Furthermore, plasma HDL-cholesterol concentration was significantly increased in diabetic rats treated with the extract (Mukesh *et al.,* 2015). A study by Mohamed *et al.* (2011), using different solvent showed the most active, chloroform was fractionated, and one sub fraction showed similar antidiabetic effect with metformin (Mohamed *et al.,* 2011).	Anti-inflammatory, anti-hypertensive, antioxidant, hepatoprotective, anti-cancer, gastro protective, antisebum, hyperlipidemic, analgesic, nephroprotective activity, kidney stone, edema, rheumatism, hepatitis, and jaundice	Leaves, Stem	Fresh leaves, decoction of stem	Compounds including sinensetin, eupatorin and 3'-hydroxy-5, 6, 7, 4'-tetramethoxyflavone were able to reduce blood glucose in STZ-induced diabetic rat (Mohamed *et al.,* 2011).

Panax ginseng	Araliaceae	Ginseng	Vuksan *et al.* (2000) showed that 24-month-old of treatment with 3 to 4.5g of ginseng extract decreased HbA1c by an unspecified magnitude. They showed that with 8 weeks of supplementation with an AG extracts at the dose of 1g similarly improved FPG and HbA1c. The further study by Yuan *et al.* (2012), used to select ginseng with sustainable efficacy and safety.	Anti-hypertensive, antioxidant, anti-aging, anti-fatigue, anti-inflammatory, antineoplastic, anti-stress, improve vitality, sexual dysfunctions, promote the healing process.	Roots	Decoction	Glycans including panaxans and quinquefolans were known to be hypoglycemic constituents (Yuan *et al.,* 2012). The triterpene β-glycoside, known as ginsenosides, are the major active constituents (Yuksan *et al.,* 2000; Yuan *et al.,* 2012).
Pereskia bleo	Cactaceae	Jarum tujuh bilah	The aqueous extracts of PB were proved contains apigenin 6C-glucoside and chrysin that significantly decrease the glucose level using the dose of 500 mg/kg in diabetic rats. In addition, this extract also lowered the trigliserides and total cholesterol level in diabetic rats while the level of HDL is maintained compared with the control rats (Darus and Mohamad, 2017).	Anti-proliferative, antioxidant, antimicrobial, antiviral, anti-parasitic, anti-nociceptive, anti-inflammation activities.	Leaves, Stems, Roots, Fruits	A decoction of leaves, fresh fruits	Phenolic compounds such as apigenin 6C-glucoside and chrysin which are reported to be responsible for the antidiabetic properties rats (Darus and Mohamad, 2017).
Trigonella foenum-graecum	Fabaceae	Fenugreek	A study on STZ-induced diabetic rats proved the beneficial effects of TF seed mucilage by enhancing the reduction in maltase activity during diabetes (Acharya *et al.,* 2007; Basu *et al.,* 2014; Bano *et al.,* 2016).	Antioxidant, antiulcer, anti-carcinogenic, anti-fertile activities, digestive stimulant action, hepatoprotective effect.	Leaves, Seeds	Fresh leaves and seeds	Contains galacatomannan and 4-hydroxyisoleucine (4-OH-Ile) (Acharya *et al.,* 2007; Basu *et al.,* 2014; Bano *et al.,* 2016). Steroidal compounds like glycosides and saponins were also detected.

Allium sativum	Liliaceae	Garlic	Most studies of AS show that it can reduce the blood glucose levels in diabetic mice, rats (Thomson *et al.,* 2015) and rabbits (Mahesar *et al.,* 2010; Liu *et al.,* 2012). Research towards rabbit showed that aqueous extract of AS possesses a beneficial anti-hyperglycaemic effect in alloxan-induced rabbits (Mahesar *et al.,* 2010).	Arthritis, toothache, chronic cough, constipation, parasitic infestation, snake and insect bites, gynecologic diseases, antimicrobial, cardiovascular effects, anti-cancer, antioxidant, hepatoprotection activities.	Bulb	Fresh bulb, Maceration	Volatile sulfur compounds, such as alliin, allicin, diallyl disulfide, diallyl trisulfide, diallyl sulfide, S-allyl cysteine, ajoene, and allyl mercaptan have a potential to reduce the diabetic condition (Mahesar *et al.,* 2010; Liu *et al.,* 2012).
Zingeber officinale	Zingiberaceae	Ginger	The ZO extracts possess hypoglycemic effect in alloxan (Jafri *et al.,* 2011), STZ (Ojewole, 2006; Singh *et al.,* 2009) and induced rat (Iranloye *et al.,* 2011) in type 2 diabetic rat. The corrective effect of ZO towards T1DM and T2DM is mainly due to the presence of 6-gingerol, that was suggested to possess antidiabetic effect. Its works by maintaining cell function related to receptor and membrane transport (Dhanil *et al.,* 2017) improving glucose homeostasis and increasing insulin sensitivity (Singh *et al.,* 2009; Chakraborty *et al.,* 2012) in delaying and preventing the complication of diabetes since it is protective against oxidative stress (Singh *et al.,* 2009). Furthermore, gingerol and shogaols were had potential inhibition towards the enzymes α-amylse and α-glucosidase (Asami *et al.,* 2010).	Antimicrobial, antioxidant, anticancer, anti-inflammatory, anti-atherosclerotic, anti-obesity, anti-emetic, antipyretic, anti-platelet aggregation, anti-angiogenic, anthelmintic, gastroprotective, cardiovascular effects, larvicidal, analgesic, immunomodulatory, hepatoprotective, neuroprotective activities.	Rhizome	Fresh juice	Gingerols, shogaols, β-bisabolene, (-)-zingiberene and geranial as well as mineral (Dhanil *et al.,* 2017).

Allium cepa	Liliaceae	Onion	The AC extracts can reduce blood glucose level in alloxan (Khaki *et al.,* 2010) and STZ (Khaki *et al.,* 2010; Jung *et al.,* 2011) induce diabetes rat. There are many components which are related to the antihyperglycemic effect of AC. One of the responsible components is quercetin (Asami *et al.,* 2010; Khaki *et al.,* 2010) and S-methyl cysteine sulfoxide (SMCS) (Ogunmodede *et al.,* 2012). It reduces blood sugar level by regenerating or improving pancreatic islets and possibly increases glucose release in STZ-induced diabetic rats (Khaki *et al.,* 2010; Ogunmodede *et al.,* 2012).	Antibacterial, anti-otitis, anti-salmonella, anti-vaginitis, anthelmintic, anti-atherosclerotic, antibiotic, anti-flu, anticholinesterase, anti-glaucoma, antioxidant, antihypertensive, antiplatelet, antiseptic, anti-inflammatory, anti-triglyceride, antitumor, antiviral, allrgenic, immune-stimulant activities.	Bulb, Leaves	Fresh bulb, cold water concoction of leaves	Quercetin (Asami *et al.,* 2010; Khaki *et al.,* 2010), S-methyl cysteine sulfoxide (SMCS) (Ogunmodede *et al.,* 2012).
Curcuma longa	Zingeberaceae	Turmeric	An alloxan induced diabetic rat showed that daily intake of curcumin reduces the rapid rise in blood glucose, and insulin dosage for normoglycemia (Chuengsamarn *et al.,* 2012). Curcumin in CL has been found to reduce oxidative stress in diabetes as shown by lower levels of thiobarbituric acid reactive substances, increased NADPH/NADP ratio and elevated activity of antioxidant enzyme glutathione peroxidase as well as decreased the influx of glucose into the polyol pathway (Arun and Nalini, 2000). Turmeric consists of 45% of dietary fiber. Fibers in turmeric reduce the fasting of blood sugar level by slowing down the absorption of glucose in the gastrointestinal tract (Kumar *et al.,* 2006).	Anti-fungal, antimicrobial, anti-viral, anti-inflammatory, anti-mutagenic, anti-carcinogenic, anticoagulant, hepatoprotective, antitumor, antiviral, anticancer activities.	Rhizome	Fresh juice	Curcuminoids, which include curcumin (diferuloylmethane) (Chuengsamarn *et al.,* 2012), demethoxycurcumin, and bisdemethoxycurcumin (Arun and Nalini, 2002; Kumar *et al.,* 2006).

These plants, some of which are popular *ulam*, have been generally recommended as an alternative remedy to treat or prevent T2DM. For instance, andrographolide, flavonoids glycosides like epicatechin, quercetin, catechin, myricetin, epigallocatechin gallate, polysaccharide compound galactomannan, saponin, gingerol, allicin, euganol and curcuma, dietary fibers and some minerals such as magnesium as well as amino acid such as 4-hydroxyisoleucine were found to be responsible for this effect. Unfortunately, many of these medicinal claims remain as hearsay and yet to be substantiated with proper scientific evidence.

CONCLUSION

Due to economic constraints, providing modern medical healthcare in developing countries is still a far-reaching goal in almost Southeast East countries; Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste and Vietnam. The most commonly used drugs of modern medicine such as aspirin, anti-malarial, anti-cancers, and digitalis are originated from plant sources. Out of an estimated 250 000 higher plants, less than 1% have been screened pharmacologically and very few in regard to DM (Grover *et al.,* 2002). Therefore, it is prudent to look for options in medicinal plants for diabetes as well. Scientists have been working continuously towards establishing the scientific basis of the use of certain plants in DM. A novel anti-hyperglycemic amino acid has been extracted and purified from fenugreek seeds (4-hydroxyleucine) which reportedly increases glucose-induced insulin release. The other compounds such as andrographolide, epigallocatechin-3-gallate (EGCG), galactomannan, charantin, eugenol, sinensetin, ginsenosides, S-allyl cysteine, allocin as well as flavonoids glycosides such as quercetin, catechin and apigenin 6-C-glucoside are found to be responsible for this effect. Such an ethno medical approach for diabetes is a practical, cost-effective and a logical for its can look towards a future of integrated medicine and hope that research in alternative medicine will help identify what is safe and effective rather than marginalizing, unorthodox medical claims and findings.

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