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

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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, eugenol 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), voglibose 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 (Prijiantini 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 Persokia ibio (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

<table>
<thead>
<tr>
<th>Country</th>
<th>Prevalence (%)</th>
<th>Study details</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brunei</td>
<td>12.4</td>
<td>2011, National, &gt;20 years</td>
<td>Brunei National Health and Nutritional Status Survey (2011)</td>
</tr>
<tr>
<td>Cambodia</td>
<td>5.9</td>
<td>2016, National, 30-69 years</td>
<td>World Health Organization (2016)</td>
</tr>
<tr>
<td>Indonesia</td>
<td>28.4</td>
<td>2006, Urban, 25-64 years</td>
<td>Soewondo et al. (2010)</td>
</tr>
<tr>
<td>Malaysia</td>
<td>17.5</td>
<td>2015, National, 18-69 years</td>
<td>Tee and Yap (2017)</td>
</tr>
<tr>
<td>Myanmar</td>
<td>6.6</td>
<td>2016, National, 30-69 years</td>
<td>World Health Organization (2016)</td>
</tr>
<tr>
<td>Philippines</td>
<td>14.5</td>
<td>2003, National, &gt; 20 years</td>
<td>Morales et al. (2008)</td>
</tr>
<tr>
<td>Singapore</td>
<td>10.5</td>
<td>2010, National, 18-69 years</td>
<td>Singapore National Health Survey (2010)</td>
</tr>
<tr>
<td>Thailand</td>
<td>11.9</td>
<td>2000, Rural, 30-74 years</td>
<td>Cockram (2000)</td>
</tr>
</tbody>
</table>

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 breastfeeding 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.

<table>
<thead>
<tr>
<th>Plant name</th>
<th>Family</th>
<th>Malaysian common name</th>
<th>Experimental evidence for its use in diabetes management</th>
<th>Other medicinal uses</th>
<th>Plants part(s) used</th>
<th>Traditional preparation method</th>
<th>Identified active constituent(s) for diabetes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andrographis paniculata</td>
<td>Acanthaceae</td>
<td>Hempedu bumi</td>
<td>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; Subramaniam 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).</td>
<td>Hypertension, anticancer, antidiarrheal, anti-hepatitis, anti-HIV, anti-inflammatory, antimicrobial, antimalarial, cardiovascular, cytotoxic, hepatoprotective, immunestimulatory, sexual dysfunctions.</td>
<td>Whole plant, Leaves, Aerial parts, Stems, Roots</td>
<td>Decoction, Maceration</td>
<td>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).</td>
</tr>
<tr>
<td>Plant/Species</td>
<td>Family</td>
<td>Common Names</td>
<td>Mode of Use</td>
<td>Medical Uses</td>
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<tr>
<td>Averrhoa bilimbi</td>
<td>Oxalidaceae</td>
<td>Belimbing buluh, belimbing asam</td>
<td>Fruits, leaves, flowers</td>
<td>Hypotriglyceridaemia, antilipid peroxidative, antiatherogenetic, antibacterial, antiscorbutic, antiasmotic, anti-inflammation, antihyperlipidaemic, antimicrobial, anti-fungal, anti-mutagenic, anti-osteoporotic activities.</td>
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<tr>
<td>Camellia sinensis</td>
<td>Theaceae</td>
<td>Tea</td>
<td>Leaves, infusion</td>
<td>Anti-aging, anti-Alzheimer, anti-Parkinson, anticancer, anti-stroke, cardiovascular effect, skin disorders.</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Cosmos caudatus</td>
<td>Asteraceae</td>
<td>Ulam raja</td>
<td>Whole plant, leaves, roots</td>
<td>Antioxidant, antihypertensive, anti-inflammatory, anti-hyperlipidemic, antimicrobial, anti-fungal, anti-mutagenic activities.</td>
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</table>
**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, anti-histaminic, nematicide, pesticide, anti-androgenic, hypcholesterolemic, hepatoprotective properties. Leaf, Seed
Infusion of leaves, seeds

**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, anti-ulcer, anti-polyptic, anti-fertility, hepatoprotective, anticancer, anti-inflammatory cardiovascular effects, anti-malaria activities. Fruits, Seeds, Leaves, Roots
Juicy fruit, infusion and decoction of leaves, roots

Glycosides with monosaccharide galactose clusters and other saccharides. The most active compound for antidiabetic properties is galactomannans. (Syamsudin et al., 2010).

Cucurbitane triterpenoids, momocharin, momordin (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, antihyperglycemic, cardio protective, central nervous system (CNS) depressant, memory enhancer, anti-hypercholesterolemia, hepatoprotective, anti-asthmatic, anti-thyroidic, antioxidant, anticancer, chemo preventive, radio protective, immunomodulatory, anti-fertility, anti-ulcer, anti-arthritis, anti-stress, anticitaract, 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, anticancer, 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 triglycerides 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, antulcer, anti-carcinogenic, anti-fertile activities, digestive stimulant action, hepatoprotective effect. | Leaves, Seeds | Fresh leaves and seeds | Contains galactomannan 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.**

<table>
<thead>
<tr>
<th>Bulb Fresh bulb</th>
<th>Maceration</th>
</tr>
</thead>
<tbody>
<tr>
<td>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 <em>et al.</em>, 2010; Liu <em>et al.</em>, 2012).</td>
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</tbody>
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**Zingiber 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-amylase 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.**

<table>
<thead>
<tr>
<th>Rhizome Fresh juice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gingerols, shogaols, β-bisabolene, (-)-zingiberene and geranial as well as mineral (Dhanil <em>et al.</em>, 2017).</td>
</tr>
<tr>
<td>Allium cepa</td>
</tr>
</tbody>
</table>
| 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). |}


**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-hydroxyxyleucine) 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, 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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