INTRODUCTION

Diabetes mellitus (DM), or commonly known as ‘diabetes’ is a very common metabolic disorder of human endocrine system having a significant impact on the health, quality of life and life expectancy of the patient and health care systems and is becoming alarmingly common worldwide. The estimated cases of the disease around the globe are around 6.4%, and more than 280 million people in the world suffer from diabetes. The majority affected, live in the developing world [2]. The World Health Organization (WHO) has estimated that there are 33 million diabetes cases in India, and that number will reach 80 million by 2030 [3].

This primary defect in fuel metabolism of the body has been acknowledged since ages in several early civilizations as Indian, Egyptian, Greek, Chinese, Iranian, Arabians and Spanish histories. In India, the disease was known as ‘Asrava’ during the Vedic era (600 BC) and a detailed description of it is available in Brahatita, viz. Charak Samhita, Sushruta Samhita and Vagbhatta. Astanga Harihaya (600 AD) is the first medical treatise in which we get a clear definition of ‘Madhumeha’ by mentioning glycosuria (madhviv mehati-honey like urine) [4]. The word diabetes was coined by the Greek physician Aretaeus in the first century A.D. in the 17th century.

It is an important chronic ailment characterized by profound disturbances in glucose, fat and protein metabolism which in turn results in widespread, multi-organ secondary complications that ultimately encompass virtually every system of the body and indulges every specialty of medicine [5, 6]. The disease is caused due to the failure of a number of metabolic activities in which a person shows high blood sugar, either because the body is not able to move out sugar from the bloodstream into tissues rapidly or efficiently after a meal, or because the body cells behave unresponsive to the insulin that is produced.

Etiologically two main categories of diabetes recognized are Primary diabetes and Secondary Diabetes. Primary diabetes is of two types—Insulin dependent diabetes mellitus (IDDM) in which there is a profound decrease in the number of ‘b cells’ in the islet of Langerhans, because of which there is absolute deficiency of insulin (Type 1) and Non-insulin-dependent diabetes mellitus (NIDDM) which is caused due to insulin resistances as well as loss of insulin secretion. The person with type 1 diabetes needs daily insulin treatment for his sustenance while a person with type 2 may get rid of this disease by taking oral hypoglycemic drugs or through natural diet. The symptoms of Secondary Diabetes results from factors like pancreatic dysfunction, hormonal imbalance, drugs or chemical induced reactions.

Various symptoms associated with the disease are hyperglycemia (fasting plasma glucose level > 126 mg/dl or glycylated hemoglobin A1c (HbA1c) > 6.9%) resulting in ‘polyuria’ (frequent urination), ‘polydipsia’ (increased thirst) and ‘polyphagia’ (increased hunger), glycosuria (release of glucose in urine), loss of weight, ketoacidosis (accumulation of ketone bodies in blood), ketonuria (elimination of ketone bodies in urine), acidosis (lowering of pH of blood due to circulating keto acids), dehydration and lipemia (increased levels of lipids, fatty acids and cholesterol in blood) etc. [8].

Diagnostic criteria for diabetes

The blood glucose levels of a healthy man are 80 mg/dl on fasting and up to 160 mg/dl in the postprandial state. Diabetes mellitus is characterized by recurrent or persistent hyperglycemia, and is diagnosed by demonstrating one of the following:

- fasting plasma glucose level at or above 126 mg/dl or 7.0 mmol/l plasma glucose at or above 200 mg/dl or 11.1 mmol/l two hours after a 75 g oral glucose load in a glucose tolerance test, random plasma glucose at or above 200 mg/dl or 11.1 mmol/l.

Two fasting glucose measurements above 126 mg/dl or 7.0 mmol/l or random blood sugar levels 200 mg/dl on two different occasions is considered diagnostic for diabetes mellitus. Patients with fasting sugars between 6.1 and 7.0 mmol/l (110 and 125 mg/dl) are considered to have impaired fasting glucose and patients with plasma glucose at or above 140 mg/dl or 7.8 mmol/l two hours after a 75 g oral glucose load are considered to have impaired glucose tolerance [9].

Various treatments strategies available for diabetes

Different methods to ameliorate or control diabetic symptoms, prescribed and practiced with varying degrees of success, are Drugs which lower the blood sugar and can treat the symptoms of DM known as hypoglycemic drugs. These drugs could be categorized as insulin, and insulin preparation, which is employed only...
The richness of Indian floral biodiversity and the medicinal potentials of their extracts more precisely phytochemicals and secondary metabolites have been used since ages and documented in various ancient scriptures for medicament against various ailments. Till date, rural India depends solely on herbal remedies as administering medicaments for improving cellular sensitivity for insulin, Western treatments thereby treat DM by supplementing insulin or to maintain euglycemic condition (72–126 mg/dl) [19].

Since in the development of diabetic symptoms insulin related imbalances play a most important role, pathological impact involves three key organs, i.e., pancreatic islets, liver, and skeletal muscle. Almost all anti-diabetic drug formulations aim at these organs. Absence, under-production or in sensitization of insulin can lead to severe biochemical imbalances in the metabolic control of the body fuel, glucose causing diabetes.

Western treatments thereby treat DM by supplementing insulin or administering medicaments for improving cellular sensitivity for insulin, improving insulin secretion from the pancreatic cells, preventing gluconeogenesis in the liver or some target gastric emptying regulations to maintain euglycemic condition (72–126 mg/dl) [19].

**Conventional diabetic drugs**

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**Insulin and insulin preparations**

Human insulin is a peptide hormone synthesized in the pancreas as an inactive single chain precursor proinsulin having a signal sequence responsible for its targeting to secretory vesicles and which undergoes proteolytic cleavage to form proinsulin. This proinsulin is now stored in pancreatic β-cells and in elevated levels of glucose gets secreted and cleaved by specific proteases to yield active insulin consisting of two amino acid chains A and B, which are linked by two disulfide (–S–S–) linkages. The chain A contains 21 amino acids and chain B contains 30 amino acids. The disulfide bridges are essential for its biological activity. This active insulin now starts the chemical cascade for conversion of the excess blood glucose to two storage forms—glycogen (in liver and muscle cells) and triacyl glycerols (in adipose tissue) [20].

Human insulin is an amphoteric protein, forms salts with weak acids and alkalis. Its properties such as water solubility and combining potency with proteins such as protamine and with zinc do not bring any change in its biological activity. The solubility of insulin depends on three factors, its physical state (that is, amorphous or crystalline), on the concentration of zinc and on the nature of buffer in which it is being suspended. It is not suitable for oral administration because it is inactivated by digestive enzymes. The normal human pancreas contains about 8–10 mg of insulin. In normal individuals, pancreas contains about 8–10 mg of insulin, and its secretion is low between meals and increase with each meal. The amount of insulin secreted per day in a normal human is about 40 units (286 mmol). All tissues have the ability to metabolize insulin, but 80% of exerted insulin is normally degraded in the liver and kidneys. Diabetic patients, in whom the defect seems from a paucity or apoptosis of pancreatic β-cells, completely rely on external insulin injections which could be either intravenous or subcutaneous. The dose of insulin required to control diabetes varies from patient to patient and from time to time in the same patient [4].

**Table 1: Various western drugs and their side effects in diabetes [21]**

<table>
<thead>
<tr>
<th>Drug group</th>
<th>Representative drug/s</th>
<th>Mode of action</th>
<th>Major clinical effect/s</th>
<th>Side effects reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfonfonylures</td>
<td></td>
<td>1st generation: Tolbutamide, Chlorpropamide, Acetohexamide, Tolazamide, Metformin</td>
<td>Activate receptors on the islet cells of the pancreas to release more stored insulin in response to glucose.</td>
<td>Reduced blood glucose, Hypoglycemia, weight gain</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2nd Generation: Glibenclamide, Glipizide, Gliclazide</td>
<td></td>
<td></td>
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<tr>
<td>Biguanides</td>
<td></td>
<td>Impaired hepatic gluconeogenesis, Decreased production of very-low-density lipoprotein</td>
<td>Decrease fasting glucose levels, thereby reducing hemoglobin A1c (A1C).</td>
<td>Gastrointestinal upset, including nausea, vomiting, anorexia, and diarrhea.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>glucose-lowering effects and lower triglyceride levels</td>
<td></td>
</tr>
<tr>
<td>Thiazolidinediones</td>
<td>Rosiglitazone, Pioglitazone,</td>
<td>Binds to peroxisome proliferator-activated receptors (PPARs) in cells forming drug-PPAR complex stimulate the production of proteins that increase insulin sensitivity, such as adiponectin. It also acts by blocking transcription of other proteins responsible for insulin resistance or inflammation.</td>
<td>slowdowns the absorption of carbohydrates after a meal limiting postprandial hyperglycemia an A1C reduction of 0.5–0.8% in type 2 diabetes.</td>
<td>Hepatotoxicity</td>
</tr>
<tr>
<td>α-glucosidase</td>
<td>Miglitol, Acarbose</td>
<td>Inhibits the intestinal enzyme that degrades polysaccharides into monosaccharides.</td>
<td>slow down the absorption of carbohydrates after a meal limiting postprandial hyperglycemia an A1C reduction of 0.5–0.8% in type 2 diabetes.</td>
<td>flatulence and other gastrointestinal symptoms</td>
</tr>
<tr>
<td>inhibitors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Meglitinides</td>
<td>Repaglinide</td>
<td>Augments insulin secretion</td>
<td>Glycemia control</td>
<td>weight gain, gastrointestinal disturbances, and hypoglycemia Hypoglycemia</td>
</tr>
<tr>
<td>DPP-4 inhibitors</td>
<td></td>
<td></td>
<td>Limit postprandial hyperglycemia, A1C reduction of 0.5–1% in patients with type 2 diabetes.</td>
<td></td>
</tr>
</tbody>
</table>
Oral hypoglycemic and antidiabetic drugs

Any drug which has the power and potency to treat diabetic complications upon oral administration is termed as oral hypoglycemic drug. Since insulin is ineffective orally and also is not required always (viz. NIDDM), oral agents which target or effect some or the other phenomenon which directly or indirectly affects the control of glucose metabolism may be of great help. But anyway these drugs can never show an effect if any reluctance is taken on controlled diet regime and other lifestyle management steps.

The various classes of glucose-lowering drugs include sulfonylureas, biguanides, alpha-glucosidase inhibitors, thiazolidinediones, and meglitinides [21]. These drugs may be categorized on the basis of their major action mechanism as insulin secretagogues (sulfonylureas, meglitinides), insulin sensitizers (biguanides, thiazolidinediones), α glucosidase inhibitors (miglitol, acarbose). Serum GLP-1 concentration enhancers and gastric emptying down-regulators (excantride, bimaglitate, and DPP-4 inhibitors) [19]. Though these drugs have been proved for their efficacy in controlling diabetic symptoms most of them have been reported to pose one or other physiological complication or side effects on use [table 1].

Traditional Indian herbal anti-diabetics

It is now internationally accepted and acknowledged that traditional medicines systems of India and other ancient origins report, advocate and justify the significance of floral biodiversity as an effective and reliable treatment strategy of hyperglycemia and related malfunctions.

Several disadvantages associated with insulin and synthetic drugs and their failure to divert the course of diabetic complications have opened up tremendous horizons for searching possibilities in complementary and alternative medicine (CAM) for diabetes as well as many other chronic diseases. Plants, herbs and their derivatives owing to their wide spectrum of active principles representing numerous chemical compounds hold promising potentials for their consistent usages in the treatment of Diabetes [4]. According to WHO, 21,000 plants around the globe have been reported for medicinal uses. India is posted to have an enormous medicinal flora of some 25,000 species, out of these 150 species are commercially exploited for medicinal extractions or drug formulation [22]. There are about 800 plants species reported having the probability of possessing antidiabetic potentials in the ethnobotanical surveys [23].

The antidiabetic effects of the plants are attributed to the wide range of chemicals and secondary metabolites. Reports have essayed approximately 200 pure compounds from plant sources to show blood glucose lowering effect. These compounds range vividly in chemical nature like alkaloids, carbohydrates, glycosides, flavonoids, steroids, terpenoid, triterpenoid, peptides and amino acids, lipids, phenolics, glycopeptides, and iridoids. Here we review traditional Indian herbs which are most efficiently, safely and widely accepted as a medicament for DM and source of future lead compounds for the disease with family-wise segregation of these plants [table 2].

### Table 2: Family wise segregation of the most scientifically validated antidiabetic plants

<table>
<thead>
<tr>
<th>Family</th>
<th>Plants</th>
<th>Indian vernacular name</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acanthaceae</td>
<td>Asteracantha longifolia</td>
<td>Kokilaksha, Talnakhana</td>
<td>[24]</td>
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<tr>
<td></td>
<td>Andrographis paniculata</td>
<td>Kalmegh</td>
<td>[25]</td>
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<tr>
<td></td>
<td>Barleria prionitis</td>
<td>kuranta, Vrddanti</td>
<td>[26]</td>
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<tr>
<td></td>
<td>Barleria lupulina</td>
<td>Vishayakaran</td>
<td>[27]</td>
</tr>
<tr>
<td>Amaranthaceae</td>
<td>Acharanthus aspera</td>
<td>Aghata, Khara-manjari</td>
<td>[28]</td>
</tr>
<tr>
<td></td>
<td>Aerva lanata</td>
<td>Asthambayda</td>
<td>[29]</td>
</tr>
<tr>
<td></td>
<td>Amaranthus spinosus</td>
<td>Tanduliyah, Kanta chaulli</td>
<td>[30]</td>
</tr>
<tr>
<td>Anacardiaceae</td>
<td>Mangifera indica</td>
<td>Aam</td>
<td>[31]</td>
</tr>
<tr>
<td>Annonaceae</td>
<td>Anacardium occidentale</td>
<td>Kajutak, Aguilkrit</td>
<td>[32]</td>
</tr>
<tr>
<td>Annona</td>
<td>Annona squamosa</td>
<td>Sharifa</td>
<td>[33]</td>
</tr>
<tr>
<td>Apiaceae</td>
<td>Daucus carota</td>
<td>Garjara</td>
<td>[34]</td>
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<tr>
<td></td>
<td>Coriandrum sativum</td>
<td>Dhaniya</td>
<td>[35]</td>
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<tr>
<td></td>
<td>Cuminum cuminum</td>
<td>Karavi, Krishna jeeraka</td>
<td>[36]</td>
</tr>
<tr>
<td></td>
<td>Cuminum nigrum</td>
<td>Kala jeera</td>
<td>[37]</td>
</tr>
<tr>
<td>Anacardium</td>
<td>Carum Carvi</td>
<td>Karavi, Krishna jeeraka</td>
<td>[38]</td>
</tr>
<tr>
<td>Apocynaceae</td>
<td>Feronia asafoetida</td>
<td>Hing</td>
<td>[39]</td>
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<tr>
<td></td>
<td>Catharanthus rosus</td>
<td>Sadabahar</td>
<td>[40]</td>
</tr>
<tr>
<td></td>
<td>Carissa carandas</td>
<td>Kamaranda, Karonda</td>
<td>[41]</td>
</tr>
<tr>
<td>Areaceae</td>
<td>Cocos nucifera</td>
<td>Nariyal</td>
<td>[42]</td>
</tr>
<tr>
<td>Asclepiadaceae</td>
<td>Gymnema sylvestre</td>
<td>Vrikshamla, Gur-mar</td>
<td>[43]</td>
</tr>
<tr>
<td></td>
<td>Calotropis gigantea</td>
<td>Madar</td>
<td>[44]</td>
</tr>
<tr>
<td>Asteraceae</td>
<td>Tridax procumbens</td>
<td>Khal muriya, Ghamra</td>
<td>[45]</td>
</tr>
<tr>
<td>Basellaceae</td>
<td>Basella rubra</td>
<td>Po, Safed Bachla</td>
<td>[46]</td>
</tr>
<tr>
<td>Bignonaceae</td>
<td>Tecoma stans</td>
<td>Piliya</td>
<td>[47]</td>
</tr>
<tr>
<td>Bombacaceae</td>
<td>Bombax ceiba</td>
<td>Semal</td>
<td>[48]</td>
</tr>
<tr>
<td>Brassicaceae</td>
<td>Eruka sativa</td>
<td>Safed Sarson</td>
<td>[49]</td>
</tr>
<tr>
<td></td>
<td>Brassica juncea</td>
<td>Rai</td>
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<tr>
<td>Burseraceae</td>
<td>Commiphora mukul</td>
<td>Guggul</td>
<td>[51]</td>
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<tr>
<td>Capparidaceae</td>
<td>Capparis decidus</td>
<td>Kurira, Karira</td>
<td>[52]</td>
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<tr>
<td>Compositae</td>
<td>Artemisia pallens</td>
<td>Davana</td>
<td>[53]</td>
</tr>
<tr>
<td>Chenopodiaceae</td>
<td>Beta vulgaris</td>
<td>Chukandar</td>
<td>[54]</td>
</tr>
<tr>
<td>Combretaceae</td>
<td>Terminalia arjuna</td>
<td>Arjuna</td>
<td>[55]</td>
</tr>
<tr>
<td></td>
<td>Terminalia chebula</td>
<td>Harad, Haritaki, Harra</td>
<td>[56]</td>
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<tr>
<td>Convolvulaceae</td>
<td>Ipomoea batatas</td>
<td>Shakkrand</td>
<td>[57]</td>
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<tr>
<td></td>
<td>Cressacretta</td>
<td>Rudravanti</td>
<td>[58]</td>
</tr>
<tr>
<td>Crassulaceae</td>
<td>Bryophyllum pinnatum</td>
<td>Pashanbhed, patharchatt</td>
<td>[59]</td>
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<tr>
<td>Cucurbitaceae</td>
<td>Citrullus colocynthis</td>
<td>Indravaruni, Mihendravarni</td>
<td>[60]</td>
</tr>
<tr>
<td></td>
<td>Cocina indica</td>
<td>Bimba</td>
<td>[61]</td>
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<tr>
<td></td>
<td>Cucurbita ficifolia</td>
<td>Chappan kaddu</td>
<td>[62]</td>
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<tr>
<td>Monodrica</td>
<td>Monodrica champania</td>
<td>Karela</td>
<td>[63]</td>
</tr>
<tr>
<td></td>
<td>Monodrica cambalaria</td>
<td>Athalkai, Karchikai</td>
<td>[64]</td>
</tr>
<tr>
<td></td>
<td>Monodrica dioica</td>
<td>Kakori</td>
<td>[65]</td>
</tr>
<tr>
<td></td>
<td>Cucumis satius</td>
<td>Khera</td>
<td>[66]</td>
</tr>
</tbody>
</table>
Oxalidaceae
Oleaceae
Nymphaeaceae
Nyctaginaceae
Musaceae
Myrtaceae
Myrsinaceae
Moraceae
Mimosaceae
Menispermaceae
Meliaceae
Melastomaceae
Malvaceae
Lythraceae
Logoniaceae
Liliaceae
Lamiaceae
Lauraceae
Juglandaceae
Hippocastanaceae
Hippocrateae
Guttiferae
Gentianaceae
Flacourtiaceae
Euphorbiaceae
Cupressaceae
Gramineae
Leguminosea
Papilionaceae

Averrhoa bilimbi
Schrebera swietenioides
Olea
Nymphaea
Nelumbo nucifera
Boerhavia diffusa
Musa
Psidium guajava
Eugenia jambolana
Eucalyptus globulus
Embelia ribes
Morus alba
Artocarpus heterophyllus
Ficus religiosa
Ficus bengalensis
Ficus carica
Acacia catechu
Tinospora cordifolia
Azadirachta indica
Osbeckia
Memecylon
Abelmoschus esculentus
Correa
Cajanus cajan
Pongamia
Medicago sativa
Trigonella foenum-graecum

Barbadensis
Europea
Exasperata
Sapientum
Paniculata
Corylus avellana
Garcinia
Enicostemma
Swertia chirayita
Umbellatum
Vonocula
Cynodon
Bambusa vulgaris
Hordeum Vulgare
Casearia
Prosopis cineraria
Tephrosia villosa
Clitoria ternatea
Butea monosperma
Saraca Asoca
Phaseolus vulgaris
Pongamia
Medicago sativa
Trigonella
Acacia arabica
Erythrina variegate
Caesalpinia
Pterocarpus marsupium
Mucuna
Cajanus cajan
Phyllanthus amarus
Juniperus communis
Luffa cylindrica
Luffa acutangula
Clitoria
Sida cordifolia
Hibiscus rosa
Lagerstroemia speciosa
Strychnos nux-vomica
Asparagus
Aloe
Allium cepa
Allium sativum
Clerodendron
Vitex negundo
Ocimum sanctum
Prunella vulgaris
Juglans regia
Salacia
Aesculus hippocastanum
Garcinia indica
Salvia macrocephala
Salvia reticulata
Salvia oblonga
Juglans regia
Prunus persica
Ocimum sanctum
Aloe vera
Hibiscus rosa-sinensis
Sida cordifolia
Tea trinum polium
Vitex negundo
Clerodendrum phlomidis
Clerodendrum serratum
Clerodendron infortunatum
Allium sativum
Allium cepa
Aloe barbadensis/Aloe vera
Asparagus officinalis
Logoniae
Lytbraeae
Malvaceae
Menispermaeae
Mimosaeae
Moraceae
Myricaceae
Myrtaceae
Musaceae
Nyctaginaceae
Nymphaeaeae
Oleaceae
Oxalidaceae

Kapikachhu
Vijaysar
Kantkarej, Kantikaranja
Pangara, Paribhadra
Methika
Ashabala
Karanja
Balka, Rajma
Asokah, Tamra Pallav
Pakash
Aparajit
Sarampukha
Shani
Kirmar
Yava
Bakal
Doab, arugampil
Kirata-tikta
Nahi, Maja-makka booti
Kokum, puran puli
Kanor, Bankhor
Sapttrangi
Saptachakra
Vairi, pitika
Akschota
Dharu
Tuki
Amberved
Nirgundi, Sephali
Agnimantha, Jaya
Bharangi
Tubhhamt
Bharangi
Bhinda
Faguna
Heen Anjan
Bhinda
Bhinda
Faguna
Heen Anjan
Concerns and complications of herbal treatments

Herbal medicines are very often used as therapeutic remedies in combination with allopathic drugs [178]. The potency of herbal drugs has been proved to be significant, and they have negligible side effects than the synthetic anti-diabetic drugs [179]. Although phytotherapy for Diabetes continues to be used in several countries till date but there are some facts which should not be ignored in the context of their regular use. First, only a few plants have undergone scientific or medical scrutiny. Secondly, a large number of medicinal plants possess some degree of toxicity. For example, it was reported that about one-third of medicinal plants used in the treatment of diabetes are considered to be toxic [180]. Thirdly, the test results of hypoglycemic plants are subject to several factors. Like, each herb contains thousands of components, only a few of which may be therapeutically effective [181]. Different parts of a herb have different ingredient profiles. Moreover, different extraction methods may yield different active ingredients [182]. Also herbal formulae containing multiple herbs may have synergistic effects [183] and enzymatic glycation of proteins generates a condition of high oxidative stress in the patient which in turn produces stress-induced damage of cellular organelles, enzymes, increased lipid peroxidation and insulin resistances [187]. DM has been a target for study and multiple therapy options since ages, and several effective therapies have been documented for its treatment and control. Recently because of much growing mass awareness about prominent side-effects of western treatments, attentions are concentrating on plant based treatments including whole drug and poly herbal formulations.

Plant-based medicinal products have been known to man since ancient times [188]. Plants have been the primary source of drugs and lead compounds, and many of the currently available drugs have been directly or indirectly derivatized from them. The families of plants with the most potent and also widely studied hypoglycemic effects include Leguminosae, Lamiaceae, Liliaceae, Cucurbitaceae, Asteraceae, Moraceae, Rosaceae, Euphorbiaceae, and Araliaceae. The plant kingdom is owing to a wide spectrum of its phytol antioxidants and medicinal potency exhibit tremendous opportunity to reduce the oxidative stress induced symptoms of diabetes mellitus.

Scientific findings on the action mechanisms of the plant compounds have proposed many means in which they act to provide the anti-hyperglycemic and anti-hyperlipidemic effects. Some of them relate their effects on the activity of pancreatic β cells (synthesis, release, cell regeneration/revitalization) or the increase in the protective/inhibitory effect against insulinase and the increase of the insulin sensitivity or the insulin-like activity of the plant extracts. Other mechanisms involve improved glucose homeostasis including protective/inhibitory effect against insulinase and the increase of the insulin sensitivity or the insulin-like activity of the plant extracts. The plant kingdom is owing to a wide spectrum of its phytol antioxidants resulting in vast medicinal potency exhibit tremendous opportunity to reduce the oxidative stress induced symptoms of diabetes mellitus.

DIscussion

Diabetes mellitus is the most common multifactorial chronic disease. High levels of free radicals and malfunction in antioxidant defence mechanism formed as a result of glucose oxidation and non-enzymatic glycation of proteins generates a condition of high oxidative stress in the patient which in turn produces stress-induced damage of cellular organelles, enzymes, increased lipid peroxidation and insulin resistances [187]. DM has been a target for study and multiple therapy options since ages, and several effective therapies have been documented for its treatment and control. Recently because of much growing mass awareness about prominent side-effects of western treatments, attentions are concentrating on plant based treatments including whole drug and poly herbal formulations.

Plant-based medicinal products have been known to man since ancient times [188]. Plants have been the primary source of drugs and lead compounds, and many of the currently available drugs have been directly or indirectly derivatized from them. The families of plants with the most potent and also widely studied hypoglycemic effects include Leguminosae, Lamiaceae, Liliaceae, Cucurbitaceae, Asteraceae, Moraceae, Rosaceae, Euphorbiaceae, and Araliaceae. The plant kingdom is owing to a wide spectrum of its phytol antioxidants resulting in vast medicinal potency exhibit tremendous opportunity to reduce the oxidative stress induced symptoms of diabetes mellitus.

Scientific findings on the action mechanisms of the plant compounds have proposed many means in which they act to provide the anti-hyperglycemic and anti-hyperlipidemic effects. Some of them relate their effects on the activity of pancreatic β cells (synthesis, release, cell regeneration/revitalization) or the increase in the protective/inhibitory effect against insulinase and the increase of the insulin sensitivity or the insulin-like activity of the plant extracts. Other mechanisms involve improved glucose homeostasis including protective/inhibitory effect against insulinase and the increase of the insulin sensitivity or the insulin-like activity of the plant extracts. The plant kingdom is owing to a wide spectrum of its phytol antioxidants resulting in vast medicinal potency exhibit tremendous opportunity to reduce the oxidative stress induced symptoms of diabetes mellitus.

**Table 1**

<table>
<thead>
<tr>
<th>Biophytium sensittivum</th>
<th>Jallapushpa, Lajjulu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxalis corniculata</td>
<td>Changeri, Amlapatikra</td>
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<td>Pandanus amaryllifolius</td>
<td>Rampe</td>
</tr>
<tr>
<td>Piper longum</td>
<td>Pippali</td>
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<tr>
<td>Piper betel</td>
<td>Tambuli</td>
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<td>Piper nigrum</td>
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<td>Picrorrhiza kurrooa</td>
<td>Katuka katurroini</td>
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<tr>
<td>Bacoap monnieri</td>
<td>Brahmii</td>
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<tr>
<td>Adiantum capillus veneris</td>
<td>Hansraj</td>
</tr>
<tr>
<td>Primula denticulata</td>
<td>drumstick primula</td>
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<td>Punica granatum</td>
<td>Dalima, Aana</td>
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<tr>
<td>Nigella sativa</td>
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<td>Ber, Badri</td>
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<td>Zizyphus nummulaiar</td>
<td>Jhar Beri</td>
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<tr>
<td>Rhizophora mucronata</td>
<td>Kullalaji, Kala Lakri</td>
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<td>Eriodocysta japonica</td>
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<tr>
<td>Prunus amygdalas</td>
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<td>Mortina citrifolia</td>
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<td>Aegle marmelosae</td>
<td>Bengul quince, Bel</td>
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<td>Murraya koenigi</td>
<td>Kadiappa</td>
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<td>Madhuca longifolia</td>
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<td>Bharat, Bhankatiya</td>
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<td>Withania somnifera</td>
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<td>Solanum nigrum</td>
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<td>Lycium barbarum.</td>
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<td>Helicteres isora L.</td>
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<td>Costus speciosus</td>
<td>Keukand, Keu</td>
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<td>Curcuma longa</td>
<td>Haridra, Haldi</td>
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<td>Tribulus terrestris</td>
<td>Gokshura</td>
</tr>
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<td>Balanites aspliatica</td>
<td>Himg, hingot</td>
</tr>
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</table>
CONCLUSION

Plants with acknowledgments in common folklore and traditional Indian medicinal systems (IMS) are very significant and medically potent in the treatment of various human ailments including Diabetes mellitus. Alternative therapies with anti-hyperglycemic effects are becoming increasingly popular among patients and are certainly significant because of the inability of conventional treatments to relieve one from the complications without having threats of additional ill-effects. Moreover, the constants like high cost and inaccessibility mostly to the rural population add up to the reasons for general inclinations towards alternative therapies. So, consuming plants with potent anti-diabetic activity for the treatment of diabetes is now becoming very popular macrobiotics treatment regime for diabetes all over the world, as most of the times, it promises no additional pains in the form of side effects. This also proves a famous saying in India;

“Any disease is half way treated if the fear for its cure is gone,”

But major hindrance in the amalgamation of traditional knowledge with modern medical practices is a lack of sufficient scientific and clinical trials, especially on human subjects. It is unfortunate that even though plant based drugs have tremendous medicinal priority over synthetic drugs, but the significant trials are not adequately available in order to advocate their scientific merit and supremacy over the existing drugs. Nonetheless, it should never be ignored that there are always possibilities of any adverse herb-drug interaction in the case of patients also receiving conventional anti-diabetic medications [21]. This review has presented a comprehensive list of a few scientifically validated anti-diabetic plants. There are absolute possibilities for developing novel and useful drugs, formulations and lead compounds from these plants. Also, some specific genetic markers which can account for the phylogenetic relationship between the different plants and families owing to the anti-diabetic character could be developed in near future which would narrow up and limit the studies and searches for herbal drug development. The scope of utilizing chemoinformatics and bioinformatics to test the harnessable and adverse synergistic behavior of various herbs and their components would also help to define the clear-cut outline of drug designing and clinical research.

CONFLICT OF INTERESTS

Declared none

REFERENCES


