ETHNO MEDICINE IN DIABETES MANAGEMENT: A REVIEW

Kishalay Jana¹, Debidas Ghosh¹*

¹Dept. of Bio Medical Laboratory Science and Management, Vidyasagar University, Midnapore-721102.

ABSTRACT

The term diabetes mellitus describes a metabolic disorder of multiple etiologies characterized by chronic hyperglycemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action or both. The effects of diabetes mellitus include long-term damage, dysfunction and failure of various organs. Diabetes mellitus may present with characteristic symptoms such as thirst, polyuria, blurring of vision, and weight loss. Experimentally, many herbs have been recommended for treating diabetes. In majority of cases, the recommendations are based on animal studies and limited pieces of evidence exist about their clinical usefulness. This review focused on the herbs, the hypoglycemic actions of which have been supported by three or more clinical studies. The search was done in NCBI Pub Med, Google Scholar, Medline and Science Direct databases using the key terms Glucose, diabetes, plants, herbs, animals, patients. According to the different clinical studies, Eugenia jambolana, Aegle marmelos, Allium cepa, Gymnema sylvestre, Momordica charantia, Ocimum sanctum, Nigella sativa, Salacia reticulate, Silybum marianum and Trigonella foenum-graecum have shown Antihyperglycemic activity and in some cases, hypolipidemic activities in diabetic patients. Among them, Eugenia jambolana, Gymnema sylvestre, Momordica charantia, Silybum marianum and Trigonella foenum-graecum have acquired enough reputation for managing diabetes. Thus, it seems that physicians can rely on these herbs and advise for the patients to improve management of diabetes.

KEY WORDS: Antidiabetic, Hypolipidemic, Medicinal Plants.
INTRODUCTION

Diabetes mellitus is a multifarious disorder that characterized by hyperglycemia resulting from malfunction in insulin secretion and/or insulin action with impaired metabolism of carbohydrate, protein and lipids [1]. The chronic hyperglycemia of diabetes is associated with long term damage, dysfunction and failure of various organs [2]. Both type 1 and type 2 diabetes mellitus are heterogeneous diseases with alterations in many genes and their products. Research on phytomolecule as diabetic remedies is uprising gradually as these are with minimal side effects in clinical experience, effectiveness and relatively low costs [3-5]. World Health Organization (WHO) recommended the use of plant drugs for different diseases, including diabetes mellitus. Therefore, studies with plant extracts are useful to know their efficacy and mechanism of action and safety. So, many reviews have been published in the last few years on plants screened for hypoglycemic activity in India [6-7]. Generally, diabetes is classified to two main types: type-1 diabetes (T1D), previously known as insulin-dependent diabetes mellitus, and type-2 diabetes (T2D), formerly called non-insulin-dependent diabetes mellitus. Patients with T1D show a state of insulin deficiency because of severe defect in islet β-cell function while T2D is characterized by a combination of resistance to action of insulin and insufficiency in insulin secretion [8]. Both types of diabetes lead to serious complications in the body, which include nephropathy, retinopathy, neuropathy, dyslipidemia and cardiovascular diseases [8, 9]. Currently, beside insulin, the most widely used medication for diabetes are oral hypoglycemic drugs including insulin sensitizers (biguanides, thiazolidinediones), insulin secretagogues (sulfonylureas, meglitinides), α-glucosidase inhibitors, incretin agonists and dipeptidyl peptidase-4 inhibitors [10]. Although early onset complications of diabetes can be controlled by oral hypoglycemic drugs/insulin treatment, serious late onset complications emerge in many patients [11]. Furthermore, clinical uses of the current drugs are accompanied by unpleasant side effects such as severe hypoglycemia, lactic acidosis, peripheral edema and abdominal discomfort [10]. Therefore, the search for new antidiabetic agents with more effectiveness and less side effects has been continued. Medicinal plants have always been an important source for finding new remedies for human health problems. Traditionally, numerous herbs have been recommended for treatment of diabetes. Also, antidiabetic effects of so many plants have been reported by many researchers. In most cases, however, these reports are confirmed by animal models and even in vitro studies and limited evidence exists about their
clinical usefulness. The current review focused on the medicinal plants, the hypoglycemic actions of which have been supported by different clinical studies on diabetic patients.

**Methodology**

To search out the different articles, we used the databases of NCBI Pub Med, Google Scholar, Medline and Science Direct, using the key terms diabetes, plants, herbs, glucose and Patients. Different medicinal plants with antihyperglycemic actions shown by at least three clinical studies were incorporated in the manuscript.

**Eugenia Jambolana**

In the last few years there has been an exponential growth in the field of herbal medicine, and these drugs are gaining popularity in both developing and developed countries because of their natural origin and lesser side effects. *Syzygium cumini* syn. *Eugenia jambolana* (*E. jambolana*), *Syzygium jambolana*, *Eugenia cumini*, *Syzygium jambos*), commonly known as jamun in India, is an evergreen tree distributed throughout the Indian subcontinent, Southeast Asia and East Africa. It is mainly utilised as a fruit producer and for its timber. Medicinally, the fruit is reported to have antidiabetic, antihyperlipidaemic, antioxidant, antiulcer, hepatoprotective, antiallergic, antiarthritic, antimicrobial, anti-inflammatory, antifertility, antipyretic, antiplaque, radioprotective, neuropsychopharmacological, nephroprotective and antidiarrhoeal activities. Among these beneficial physiological effects, the antidiabetic property of *S. cumini* has the most promising nutraceutical value. The health-beneficial effects of *S. cumini* are mainly attributed to various phytoconstituents such as tannins, alkaloids, steroids, flavonoids, terpenoids, fatty acids, phenols, minerals, carbohydrates and vitamins present in the fruit.

The LH II fraction purified from ethanolic seed extract of *S. cumini* restored the decreased activities of glycolytic enzymes (glucokinase and phosphofructokinase) and increased the activities of gluconeogenic enzymes (glucose-6-phosphatase and fructose-1,6-bisphosphatase) to their normal levels in alloxan induced diabetic rabbits. Thus LHII-induced activation of glycolysis resulted in increased consumption of glucose by restoring insulin secretion in treated rabbits. Insulin is also a suppressor of gluconeogenic enzymes, which could be a reason for the LH II mediated reduction in the activities of gluconeogenic enzymes. The mechanism of action of LH II was observed to be both pancreatic and extra-pancreatic, as *E. jambolana* is reported to inhibit insulinase activity in both the liver and kidney. Treatment of diabetic rats with *E. jambolana* aqueous lyophilised seed powder
extract led to increased hepatic and skeletal muscle glycogen contents but no significant change in renal glycogen content compared with diabetic controls. It also caused a significant rise in the levels of certain enzymes, namely hexokinase, glucokinase and phosphofructokinase, and substrate, glucose-6-phosphate, in comparison with diabetic controls. The antihyperglycaemic activity of seeds of *E. jambolana* and its prevention of glycogen depletion in the liver and muscle were also explained as being possibly due to either stimulation of insulin release from β cells or insulin mimetic activity of some components of the fruit, resulting in direct peripheral glucose uptake, or due to a combination of the two [13]. Inhibition of pancreatic α-amylase activity by aqueous *S. cumini* seed extract has been reported to be a possible mechanism for its antidiabetic action [14]. Oral administration of ethyl acetate fraction of seed of *E. jambolana* significantly lowered blood glucose and urine sugar levels of diabetic rats. The said fraction treatment also elevated plasma insulin and C-peptide levels in diabetic groups. Insulin and C-peptide are the products of enzymatic cleavage of proinsulin and are secreted into the circulation in equimolar concentrations. Measurement of both C-peptide and insulin levels has been reported to be a more valuable index of insulin secretion than measurement of insulin alone [15-16]. There was a significant gain in body weight of treated rats compared with diabetic control animals, which might be due to the protective effect of fraction in controlling muscle wasting (i.e. reversal of gluconeogenesis and glycogenolysis) and also due to the improvement in insulin secretion and glycaemic control. An immunohistochemical staining study revealed positive staining for insulin in epithelia of the pancreatic duct and in cells around the duct in diabetic rats treated with aqueous extract of *S. cumini* bark at a dose of 1 g kg-1 BW for 30 days. This effect was not seen in control groups, suggesting the possibility that *S. cumini* can stimulate β cell regeneration by proliferation of its precursor cells in the pancreatic duct, since practically all its β cells were destroyed by alloxan [17].

**Table-1: Best Herbs for Managing Diabetes**

<table>
<thead>
<tr>
<th>Herbs</th>
<th>Cases</th>
<th>Study Design</th>
<th>Effects</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aegle marmelos</em></td>
<td>T2D T2D</td>
<td>Controlled trial</td>
<td>↓PPBG</td>
<td>Ismail, 2009a</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>Controlled trial</td>
<td>↑Oral hypoglycemic drugs actions</td>
<td>Ismail, 2009b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Controlled trial</td>
<td>↑Oral hypoglycemic drugs actions</td>
<td>Kumar et al., 2013</td>
</tr>
<tr>
<td><em>Allium cepa</em></td>
<td>T2D T1D&amp;T2D</td>
<td>Pre- &amp; Post-treatment</td>
<td>↓blood glucose 2 h after sugar ingestion</td>
<td>Myint <em>et al.</em>, 2009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Controlled trial</td>
<td>↓FBG, ↑Glucose tolerance</td>
<td>Eldin, <em>et al.</em>, 2010</td>
</tr>
<tr>
<td>Plant Name</td>
<td>Type</td>
<td>Treatment Details</td>
<td>Effects</td>
<td>Authors</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------</td>
<td>-----------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td><em>Gymnema sylvestre</em></td>
<td>T1D T2D</td>
<td>Controlled trial</td>
<td>↓Insulin actions, ↑Oral hypoglycemic drugs actions, ↓FBG, ↓PPBG, ↓HbA1c, ↓FBG, ↑PPBG</td>
<td>Shanmugasundaram et al., 1990</td>
</tr>
<tr>
<td></td>
<td>T2D T2D</td>
<td>Pre- &amp; Post-treatment</td>
<td></td>
<td>Baskaran et al., 1990</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>Controlled trial</td>
<td></td>
<td>Al-Romaiyan et al., 2010</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>Pre- &amp; Post-treatment</td>
<td></td>
<td>Paliwal et al., 2009</td>
</tr>
<tr>
<td><em>Momordica charantia</em></td>
<td>T1D&amp;T2D</td>
<td>Pre- &amp; Post-treatment</td>
<td>↓PPBG, ↓FBG, ↓PPBG, ↓FBG, ↓HbA1c, ↓FBG, ↓Liver enzymes, ↓Retinopathy, ↓stroke, ↓Fructosamine, Without significant effects</td>
<td>Grover et al., 1990</td>
</tr>
<tr>
<td></td>
<td>T2D T2D</td>
<td>Pre- &amp; Post-treatment</td>
<td></td>
<td>Ahmad et al., 1999</td>
</tr>
<tr>
<td></td>
<td>T2D T2D</td>
<td>Pre- &amp; Post-treatment</td>
<td></td>
<td>Sirvastava et al., 1993</td>
</tr>
<tr>
<td></td>
<td>T2D T2D</td>
<td>Pre- &amp; Post-treatment</td>
<td></td>
<td>Joseph and Jini, 2013</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>Controlled trial</td>
<td></td>
<td>Waheed et al., 2008</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>Pre- &amp; Post-treatment</td>
<td></td>
<td>Rahman et al., 2009</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>Controlled trial</td>
<td></td>
<td>Fuangkan et al., 2011</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>RDBP trial</td>
<td>↓FBG, ↓Lipids, ↓Oral hypoglycemic drugs actions, ↓FBG, ↓Liver pressure</td>
<td>Dans et al., 2007</td>
</tr>
<tr>
<td><em>Nigella sativa</em></td>
<td>MS T2D</td>
<td>Controlled trial</td>
<td>↓FBG, ↓Lipids, ↓Oral hypoglycemic drugs actions, ↓FBG, ↓Liver pressure</td>
<td>Najmi et al., 2008</td>
</tr>
<tr>
<td></td>
<td>T2D T2D</td>
<td>Pre- &amp; Post-treatment</td>
<td></td>
<td>Bilal et al., 2009</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>Controlled trial</td>
<td></td>
<td>Bamosa et al., 2010</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>Pre- &amp; Post-treatment</td>
<td></td>
<td>Qidwai et al., 2009</td>
</tr>
<tr>
<td><em>Eugenia jamboalna</em></td>
<td>T1D</td>
<td>Controlled trial</td>
<td>↓FBG, ↓HbA1c, ↓Oral hypoglycemic drugs actions, ↓FBG, ↓Liver pressure</td>
<td>Ghosh et al., 2014</td>
</tr>
<tr>
<td></td>
<td>T1D</td>
<td>Controlled trial</td>
<td></td>
<td>Jana et al., 2014</td>
</tr>
<tr>
<td><em>Salacia reticulata</em></td>
<td>T2D T2D</td>
<td>RDBP trial</td>
<td>↓FBG, ↓HbA1c, ↓Liver enzymes, ↓Liver enzymes, ↓Oral hypoglycemic drugs actions, ↓Random BG, ↓Liver enzymes</td>
<td>Kajimoto et al., 2000</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>RDBP trial</td>
<td></td>
<td>Jayawardena et al., 2005</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>RDBP trial</td>
<td></td>
<td>Radha et al., 2009</td>
</tr>
<tr>
<td><em>Silybum marianum</em></td>
<td>T2D T2D</td>
<td>RDBP trial</td>
<td>↓FBG, ↓HbA1c, ↓Liver enzymes, ↓Liver enzymes, ↓Oral hypoglycemic drugs actions, ↓Random BG, ↓Liver enzymes</td>
<td>Fallah et al., 2008</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>RDBP trial</td>
<td></td>
<td>Hussain, 2007</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>RDBP trial</td>
<td></td>
<td>Jose et al., 2011</td>
</tr>
<tr>
<td><em>Trigonella foenum</em></td>
<td>T1D T2D</td>
<td>Cross over trial</td>
<td>↓FBG, ↓Liver enzymes, ↓Liver enzymes, ↓Oral hypoglycemic drugs actions, ↓Random BG, ↓Liver enzymes</td>
<td>Sharma et al., 1990b</td>
</tr>
<tr>
<td></td>
<td>T2D T2D</td>
<td>Cross over trial</td>
<td></td>
<td>Sharma et al., 1990a</td>
</tr>
<tr>
<td></td>
<td>T2D</td>
<td>Cross over trial</td>
<td></td>
<td>Ismail et al., 2009</td>
</tr>
</tbody>
</table>

FBG: fasting blood glucose; MS: Metabolic syndrome; PPBG: postprandial blood glucose; RDBP: Randomized double-blind placebo; RSBP: Randomized Single-blind placebo; T1D: type-1 diabetes; T2D: type-2 diabetes; ↓: Decrease; ↑: Increase.

**Momordica charantia (M. charantia)**

*Momordica charantia* (Karela, Ampalaya, bitter melon, bitter gound) has acquired a
reputation for management of diabetes. It has passed several animal studies and its clinical trials have been started since many years ago. Administration of *M. charantia* seeds to six T1D and fourteen T2D patients significantly decreased PPBG level in both patient groups [18]. Also, drinking an aqueous suspension of the vegetable pulp resulted in remarkable reduction of FBG and PPBG levels in 86 out of 100 cases with moderate T2D [19]. Similarly, fruit juice of *M. charantia* was found to significantly improve glucose tolerance in 73% of eighteen maturity onset diabetic patients. In a case series study, diabetic patients were given aqueous extract (7 cases) or dried powder (5 cases) of *M. charantia* fruit, as a single dose or thrice a day, respectively. After 3 weeks, the extract and powder caused 54% and 25% reduction in mean blood glucose, respectively [20]. Also, HbA1c was reduced from 8.37 to 6.1% by the extract. In line with these findings, Joseph and Jini (2013) [21] found a decreased HbA1c in 9 patients with T2D who consumed fried *M. charantia* fruits (0.23 kg/day for 8-11 weeks) and also an improvement of glucose tolerance in the patients who had taken 50 ml of *M. charantia* juice. Consumption of dried powder of *M. charantia* fruit showed reduction in FBG of 10 T2D patients with no history of previous medication and 10 T2D patients with history of taking oral hypoglycemic agents. The same effect was also obtained with aqueous and alcoholic extracts of *M. charantia* fruit [22]. Recently, Rahman *et al.* (2009) compared effects of *M. charantia* and rosiglitazone, a thiazolidinedione derivative, between 25 T2D patients treated with *M. charantia* juice (55 mL/day for 5 months) [23]. The study showed that *M. charantia* was more effective in the management of diabetes (FBG, total cholesterol and serum sialic acid) and its related complications (retinopathy and myocardial infarction) than rosiglitazone. On the other hand, Fungchan *et al.* (2011) reported that hypoglycemic effect of *M. charantia* was less than metformin [24]. Besides, in their multicenter randomized double-blind study, fructosamine level significantly decreased in T2D patients who received *M. charantia* for 4 weeks. Unlike the above mentioned studies, Dans *et al.* (2007) reported no significant decrease in FBG and total cholesterol level of T2D patients treated with a *M. charantia* product (2 capsules/three times daily) given for 3 months. They only observed a 0.24% decline in HbA1c following the intervention [25].

*Aegel marmelos* (*A marmelos*)

*Aegle marmelos*, also known as bael, has been reported to have a number of medicinal attributes including antidiabetic effects. In a study by Ismail (2009a), twenty T2D patients with postprandial blood glucose (PPBG) of 201 ± 6 mg/dL were given decoction of 5 g A.
marmelos leaf powder once a day. After 16 weeks, their PPBG significantly decreased to 159 ± 5 mg/dL. In another study, it was also shown that this decoction (5 g/day for 1 month) potentiated hypoglycemic effect of standard oral drugs in T2D patients (Ismail, 2009b).

**Allium cepa (A. cepa)**

Preliminary, Mathew and Augusti (1975) reported that oral consumption of Allium cepa (onion) can improve glycemic control in diabetes. Acute hypoglycemic effect of A. cepa was also observed in a self-controlled study on twenty patients with T2D. It was also able to attenuate (37%) rise in plasma glucose 2 h after glucose ingestion. More recently, it was shown that intake of 100 g A. cepa can decrease FBG level and improve glucose tolerance test (GTT) in both T1D and T2D patients.

**Gymnema sylvestra (G. Sylvestra)**

Accumulating pieces of evidence demonstrates that leaves of Gymnema sylvestre (Gurmar, Meshashringi, Merasingi, Kavali, Dhuleti) can improve glycemic control in diabetes. Shanmugasundaram et al. (1990) evaluated effectiveness of G. sylvestre leaf extract in controlling hyperglycaemia in 27 T1D patients under insulin therapy. The extract (400 mg/day for 18 months) significantly decreased FBG, HbA1c and serum lipids of the patients when compared with a similar group who received only insulin. Also, administration of this extract (400 mg/day for 18-20 months) as a supplement to conventional oral hypoglycemic drugs reduced FBG and HbA1c of T2D patients and drug dosage could be decreased. In another trial, treatment of T2D patients with a G. sylvestre-based product (1 g/day for 2 months) led to significant decreases in FBG and PPBG levels which were accompanied by increases in circulating insulin and C-peptide. Moreover, it stimulated insulin secretion from isolated human islets of Langerhans (Al-Romaiyan et al., 2010). A mild decrease in FBG (1%) and PPBG (1%) levels was also seen in T2D patients (20 cases) treated for 4 weeks with 6 g/day of G. sylvestre leaf powder.

**Nigella sativa (N. sativa)**

Seeds of Nigella sativa (black seed) have been used for centuries as a natural remedy for various ailments. Hypoglycemic, antioxidant, hypotensive, hypolipidemic and antimicrobial effects of N. sativa have been experimentally reported. With clinical studies, its therapeutic effect in metabolic syndrome and diabetes has been shown in recent years. In a study, N. sativa seeds (1, 2 or 3 g/day) were added to antidiabetic drugs of 94 T2D patients. After three months, a significant reduction occurred in FBG, PPBG and HbA1c
levels [37].

**Salacia reticulate (S. reticulata)**

It has been shown that a diet containing aqueous extract from the stem of Salacia reticulate (240 mg/day for 6 weeks) can decrease FBG and HbA1c levels in T2D patients [38]. Also, a significant reduction in HbA1c has been reported in the patients receiving a preparation of S. reticulate tea for 3 months [39]. Clinical usefulness of S. reticulate consumption (2 g/day for 3 months) in the management of diabetes has been also observed in 30 patients [40].

**Silybum marianum (S. marianum)**

The fame of Silybum marianum (milk thistle) seed in herbal medicine is owing to its therapeutic effects for liver-related disorders. However, beneficial effects of S. marianum and its flavonolignans (silymarin) on reducing glucose and lipids have been also shown in diabetic patients [41]. In a 2-month randomized double blind clinical study, silymarin (200 mg thrice a day) could decrease FBG, HbA1c, total cholesterol, LDL, TG, serum glutamic oxalacetic transaminase (SGOT) and serum glutamic pyruvic transaminase (SGPT) in T2D patients (30 cases) receiving conventional therapy [42]. Reduction in glucose, lipids and hepatic enzymes is consistent with the results of another trial on 25 T2D patients receiving the same dose of silymarin for 4 months [43]. Beneficial effects of silymarin (200 mg/day) on FBG, HbA1c and PPBG have been also seen in T2D patients maintained on glibenclamide [44]. It has been also reported that silymarin administration to diabetic patients with liver disease could reduce insulin resistance, endogenous insulin production and need for exogenous insulin administration [45].

**Trigonella foenum-graecum (T. foenum-graecum)**

Hypoglycemic effect of Trigonella foenum-graecum (fenugreek) seeds has been demonstrated in cell culture, animal models and human with more than 30 studies [46]. In human studies, usefulness of fenugreek seeds has been reported in management of both T1D and T2D. Ismail (2009a) extended period of study to 16 weeks, administrated 20 g/day of T. foenum-graecum seeds to 20 non-insulin dependent diabetic patients and reported a significant decrease in PPBG level [26]. In a double blind placebo trial, T2D patients (46 cases) were given sulfonylureas drug plus T. foenum-graecum seeds (in the form of pill; 6 pills/3 times per day) or sulfonylureas drug plus placebo (23 cases). After 12 weeks, the combined therapy had more effect on level of FBG, HbA1c and PPBG [47].
In this study, a single dose of whole seeds, defatted seeds, gum isolate and cooked seeds (but not degummed seeds) of *T. foenum-graecum* was also able to prevent the rise of plasma glucose after meal or glucose ingestion in non-diabetic subjects. Unlike the seeds, effect of *T. foenum-graecum* leaves on reducing blood glucose level was not consistent. While Sharma (1986) observed negative results with cooked leaves \(^{[48]}\), reported that 40 mg/kg of aqueous extract of *T. foenum-graecum* leaves can diminish blood glucose level of healthy subjects 4 h after ingestion, which may be due to methodological issues such as difference in methods of extract preparation \(^{[49]}\).

**CONCLUSION**

Plants have always been an important source for finding new remedies for human diseases. Among hundreds of plants that have been studied for diabetes, only a small fraction has been tested in animal studies and is under clinical trials. The plants described in this paper, particularly *Eugenia jambolana*, *Gymnema sylvestre*, *Momordica charantia* and *Trigonella foenum-graecum*, had some clinical evidence for their antidiabetic effects. Therefore, it seems that physicians can rely on these herbs, at least as complementary therapeutics, along with current hypoglycemic drugs to improve management of diabetic patients.

**ACKNOWLEDGEMENT**

The financial support from Department of Science & Technology (DST), Govt. of India (Project No.-SR/SO/ HS-171/2010 (G) to conduct this project work is gratefully acknowledged.

**CONFLICT OF INTEREST**

The authors have declared that there is no conflict of interest.

**REFERENCES**


38. Kajimoto O, Kawamori S, Shimoda H, Kawahara Y, Hirata H, Takahashi T. Effects of a diet containing Salacia reticulata on mild type 2 diabetes in humans. A placebo-


46. Ghorbani A, Rakhshandeh H. The most effective herbs for diabetes. Mashhad: Mashhad University of Medical Sciences Publisher, 2012; 21-127.

