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## Document heading

## Current status of Indian medicinal plants with antidiabetic potential: a review

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## ABSTRACT

In India, indigenous remedies have been used in the treatment of diabetes mellitus since the time of Charaka and Sushruta. Plants have always been an exemplary source of drugs and many of the currently available drugs have been derived directly or indirectly from them. The ethnobotanical information reports that about 800 plants may possess anti-diabetic potential. Out of several Indian medicinal plants 33 plants were reviewed. The most effective antidiabetic Indian medicinal plants are *Acacia arabica*, *Aegle marmelose*, *Agrimonia eupatoria*, *Allium cepa*, *Allium sativum*, *Aloe vera*, *Azadirachta indica*, *Benincasa hispida*, *Beta vulgaris*, *Caesalpinia bonducella*, *Citrullus colocynthis*, *Coccinia indica*, *Eucalyptus globules*, *Ficus bengalensis*, *Gymnema sylvestre*, *Hibiscus rosasinesis*, *Ipomoea batatas*, *Jatropha curcus*, *Mangifera indica*, *Momordica charantia*, *Morus alba*, *Mucuna pruriens*, *Ocimum sanctum*, *Pterocarpus marsupium*, *Punica granatum*, *Syzgium cumini*, *Tinospora cordifolia*, *Trigonella foenum graecum*. A wide array of plant derived active principles representing numerous chemical compounds has demonstrated activity consistent with their possible use in the treatment of diabetes.

## 1. Introduction

Diabetes mellitus is a chronic endocrine disorder caused by an absolute or relative lack of insulin and/or reduced insulin activity that results in hyperglycemia and abnormalities in carbohydrate, fat and protein metabolism. Diabetes has emerged as a major healthcare problem in India. A national urban survey in 2005 observed that the prevalence of diabetes in urban India in adults was 15.1%. Recent data have illustrated the impact of socio-economic transition occurring in rural India. The transition has occurred in the last 15 years and the prevalence has risen from 2.4% to 6.4%[1].

In India, indigenous remedies have been used in the treatment of diabetes mellitus since the time of Charaka and Sushruta. Plants have always been an exemplary source of drugs and many of the currently available drugs have been derived directly or indirectly from them. The ethnobotanical information reports that about 800 plants may possess anti-diabetic potential[2]. Several such herbs have shown anti-diabetic activity when assessed using presently

available experimental techniques. A wide array of plant derived active principles representing numerous chemical compounds has demonstrated activity consistent with their possible use in the treatment of insulin dependent diabetes mellitus. Among these are alkaloids, glycosides, galactomannan gun, polysaccharides, peptidoglycans, hypoglycans, guani-dine, steroids, carbohydrates, glycopeptides, terpenoids, amino acids and inorganic ions. Even there is the discovery of widely used hypoglycemic drugs, metformin came from the traditional approach by using *Galega officinalis*. Thus, plants are a potential source of antidiabetic drugs (and others too) but this fact has not gained enough momentum in the scientific community. Out of the several medicinal plants used in the treatment of diabetes, some were reviewed in the present study[3–6].

## 2. Adverse effects of current treatment

Currently insulin and oral hypoglycemic agents are used in the treatment of diabetes mellitus. The main undesirable effect of insulin is that hypoglycemia can cause brain damage. Swelling, erythema and stinging occur specially in the beginning. Allergy to human by insulin is unusual but can occur. Some patients develop short-lived dependent edema (due to Na<sup>+</sup> retention) when insulin

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therapy is started. The commonest unwanted effects of metformin are gastrointestinal disturbances, abdominal pain, and metallic taste. Lactic acidosis is rare but has potentially toxic effect and metformin should not be given to patients with renal or hepatic disease, hypoxic pulmonary disease, heart failure or shock. Vitamin B<sub>12</sub> deficiency due to interference with its absorption can occur with high dose of metformin. The commonest adverse effects of sulfonylureas are hypoglycemia, which can be severe and prolonged. The allergic skin rashes can occur, and bone marrow damage, although very rare can be severe. Thiazolidinediones causes serious hepatotoxicity, weight gain, gastrointestinal disturbances.

In order to overcome these problems it is essential to search new class of compounds. Several traditional medicines are used for the treatment of diabetes patients in different ethnic societies of Asia, Africa and the South America. Even in developed countries of Europe, North America and Japan, several plant products/ herbal drugs are used for the treatment of diabetes. Medicinal plants are of great importance for health of individuals and communities. The medicinal value of these plants lies in some chemical substances that produce a definite physiological action on the human body[7].

### 3. Indian medicinal plants with antidiabetic potential

#### 3.1. *Acacia arabica* (*A. arabica*) (*Leguminosae*)

Powdered seeds of *A. arabica* demonstrate significant hypoglycemic effect at 2, 3 and 4 gm/kg in normal rabbits by initiating the release of insulin from pancreatic  $\beta$  cells. No acute toxicity and behavioral changes were observed at these doses[8]. Yasir *et al* evaluated an aqueous and hydro alcoholic extracts of *A. arabica* for its hypoglycemic property and found that both extracts possess significant hypoglycemic property at 400 mg/kg[9]. The hydro alcoholic and chloroform extracts of *A. acacia* bark demonstrate significant antidiabetic property at 250 and 500 mg/kg dose dependently in alloxan induced diabetic rats[10,11].

#### 3.2. *Aegle marmelos* (*Rutaceae*)

The aqueous extract of leaf normalizes the blood glucose and lipid parameters in streptozotocin induced diabetic mice at a dose of 300 mg/kg. Also the same extract shows hypoglycemic effect by releasing insulin *in vitro*[12]. Methanolic extract of leaf and callus possesses significant antidiabetic effect at a dose of 1 g/kg in streptozotocin induced diabetic rabbits comparable to petroleum ether, benzene and chloroform extracts[13]. Oral administration of leaves of plants at 5 g/day significantly ameliorates blood glucose level in non insulin dependent diabetes mellitus patients[14].

#### 3.3. *Agrimonia eupatoria* (*Rosaceae*)

Zhang and Cheng, isolated nine compounds *viz.* apigenin-7-O- $\beta$ -D-glucopyranoside, catechin, quercetin, rutin, kaempferol-3-O- $\alpha$ -L-rhamnoside, kampferol-3-O- $\beta$ -D-glucopyranoside, luteolin-7-O- $\beta$ -D-glucopyranoside, 19 $\alpha$ , 24-dihydroxy ursolic acid,

3,3'-di-O-methyl ellagic acid-4-O- $\beta$ -D-glucopyranoside form agrimony which reduce blood glucose level[15].

#### 3.4. *Allium cepa* (*Liliaceae*)

Oral administration of juice of onion regulates blood glucose level and biochemical parameters in alloxan induced diabetic rats at a dose of 120 mg/kg. Furthermore, extract also normalizes the concentration of thiobarbituric acid reactive substances and the activity of glutathione S-transferase in plasma, liver, testes, brain, and kidney which were increased in alloxan-diabetic rats[16]. Administration of onion powder in high fat diet streptozotocin diabetic rats causes increase in insulin secretion[17]. The onion extract intake was effective in lowering plasma glucose concentrations and body weight in diabetes[18].

#### 3.5. *Allium sativum* (*A. sativum*) (*Alliaceae*)

The intraperitoneal administration of (250 mg/kg) petroleum ether, ethyl acetate and chloroform fractions of the methanol extract of garlic reveals significant antidiabetic, antihyperlipidemic and hepatoprotective properties[19]. Administration of aqueous extract of *A. sativum* to diabetic subjects causes a significant antidiabetic and hypolipidemic effect[20]. Furthermore, an administration of alcoholic extract of garlic significantly reduces *Candida albicans* concentrations in liver and kidneys homogenates in infected control and streptozotocin induced diabetic rats[21]. The herbal formulation, DRF/AY/5001, containing a garlic, elicits hypoglycemic/antidiabetic effect in both normal and experimentally induced hyperglycemia (epinephrine and alloxan) rats at a dose of 500 mg/kg[22]. Mahesar *et al* reported a significant anti-hyperglycaemic effect of garlic (1% solution/kg) in alloxan-induced rabbits[23].

#### 3.6. *Aloe vera* (*A. vera*) (*Liliaceae*)

Rajasekaran *et al* reported that, ethanol extract of *A. vera* leaf gel shows significant antihyperlipidaemic effect in streptozotocin induced diabetic rats at 300 mg/kg for 21 days[24]. The treatment of *A. vera* in diabetic rats showed a marked increase in body weight, liver glycogen, decreased blood and urine glucose levels and normalized serum lipids[25]. Oral administration of processed *A. vera* gel for 8 weeks in diet induced non insulin dependent diabetes mellitus in mice inhibits significantly plasma glucose level[26]. The high molecular weight (MW) fractions of *A. vera* containing less than 10 ppm of barbaloin and polysaccharide (MW: 1 000 kDa) with glycoprotein, verectin (MW: 29 kDa) showed a significant hypoglycemic as well as antihyperlipidaemic activity[27]. Oral administration of polyphenol-rich *A. vera* extracts (350 mg/kg) with known concentrations of aloin (181.7 mg/g) and aloe-emodin (3.6 mg/g) for 4 weeks to insulin resistant ICR mice decreases significantly both body weight and blood glucose levels[28]. The lophenol and cycloartanol, phytosterols isolated from *A. vera* gel inhibits blood glucose level at 25 g/kg/day respectively for 44 days in animal model of type-2 diabetes[29].

#### 3.7. *Azadirachta indica* (*A. indica*) (*Meliaceae*)

Administration of leaf extract of neem possesses antihyperglycemic and antidyslipidemic activity by normalizing blood glucose level and lipid parameters in streptozotocin induced diabetic rats[30,31]. The polyherbal formulation containing neem and bitter leaf possesses significant antidiabetic and antihyperlipidemic activity at 400 mg/kg[32]. The combined leaf extracts of *Vernonia amygdalina* and *A. indica* cause increase in insulin level and show antihyperglycemic action in diabetic rats[33].

### 3.8. *Benincasa hispida* (*B. hispida*) (*Cucurbitaceae*)

*B. hispida* fruit was found to be effective in oxidative stress against indomethacin induced gastric ulcer by decreasing malondialdehyde with concomitant increasing superoxide dismutase and vitamin C levels[34]. The hydro alcoholic and chloroform extracts of *B. hispida* fruit demonstrate significant antidiabetic property at 250 and 500 mg/kg dose dependently in alloxan induced diabetic rats[10,11].

### 3.9. *Beta vulgaris* (*B. vulgaris*) (*Chenopodiaceae*)

The vitexin–2000–rhamnoside, its demethylated form 200–xylosylvitexin, isorhamnetin 3–gentiobioside, and rutin of phenolic fraction, obtained from *B. vulgaris* showed no toxicity to human lymphocytes and slight toxicity to macrophages. Vitexin–2000–rhamnoside strongly inhibited DNA synthesis in MCF–7 cells, whereas 200–xylosylvitexin and isorhamnetin 3–gentiobioside were activators. Combinations of activators and inhibitors maintained the over–all inhibitory effect[35].

### 3.10. *Brassica juncea* (*Brassicaceae*)

Administration of (200 mg/kg) aqueous extract of seeds to streptozotocin induced diabetic rats daily once for one month causes significant antidiabetic and antihyperlipidaemic activity[36].

### 3.11. *Caesalpinia bonducella* (*Cisalpiniaceae*)

The fraction isolated from seeds shows hypoglycemic activity in type–2 acute diabetic models and also shows insulin secretagogue activity in isolated islets[35]. Oral administration of seed extract produces significant antihyperglycemic action due to blocking glucose absorption in alloxan induced diabetic rats at 300 mg/kg[38].

### 3.12. *Cajanus cajan* (*Fabaceae*)

The methanol extract of leaves showed significant reduction of fasting blood sugar in alloxan induced diabetic rats at 400 and 600 mg/kg in a dose–related manner[39].

### 3.13. *Capparis decidua* (*C. decidua*) (*Capparaceae*)

Alkaloid rich fraction from *C. decidua* shows antidiabetic potential in mice[40].

### 3.14. *Citrullus colocynthis* (*C. colocynthis*) (*Cucurbitaceae*)

The feeding of *C. colocynthis* oil supplementation normalizes blood glucose level in streptozotocin induced

diabetic rats by partly preserving or restoring pancreatic  $\beta$  cell mass[41]. The administration of capsules (100 mg *C. colocynthis* fruit) thrice a day for two months, causes significant reduction of blood glucose level in type–2 diabetic patients[42].

### 3.15. *Coccinia indica* (*C. indica*) (*Cucurbitaceae*)

Combined extracts of *Musa paradisiaca* and *C. indica* ameliorate indices of protein metabolic disorders in streptozotocin induced diabetes rats[43]. Aqueous extract of leaf shows antidiabetic activity in streptozotocin induced diabetes rats[44]. The ethanolic extract of aerial parts, normalizes blood glucose level and lipid parameters in streptozotocin induced diabetic rats at 100 or 200 mg/kg[45]. Chronic administration of fruit extracts (200 mg/kg) for 14 days reduces the blood glucose level in alloxan induced diabetic rats[46].

### 3.16. *Eucalyptus globulus* (*Myrtaceae*)

Administration of leaves extract to alloxan induced diabetic rats ameliorates blood glucose by enhancement of peripheral glucose uptake and oxidative stress by increase in catalase, superoxide–dismutase and glutathione–peroxidase activities in liver and kidney[47].

### 3.17. *Ficus bengalensis* (*Moraceae*)

Oral administration of aqueous bark extract (500 mg/kg) ameliorates the blood glucose level, lipid parameters and hepatic enzymes in streptozotocin induced diabetic rats[48].

### 3.18. *Gymnema sylvestre* (*Asclepiadaceae*)

The leaves extract stimulates insulin secretion *in vitro* using MIN6  $\beta$ –cell line and isolated human islets of Langerhans[49]. Aqueous leaf extract shows hypolipidemic and hypoglycemic activity in alloxan induced diabetic rats at 400–800 mg/kg[50]. The conduritrol, isolated from stem shows antidiabetic activity by increasing thymus, pancreas, splenic index or inhibiting the atrophy of thymus, pancreas, splenic index of the diabetic rats induced by alloxan[51]. The bioactivity guided isolation of novel dihydroxy gymnemic triacetate from acetone extract of *G. sylvestre* leaves possesses hypoglycemic and antihyperlipidemic property in streptozotocin induced diabetic rats[52].

### 3.19. *Hibiscus rosa–sinesis* (*Malvaceae*)

The ethanol extract of flowers at 250 and 500 mg/kg significantly reduces the blood glucose level in both acute and sub acute treatments in alloxan induced diabetic rats[53]. Fractions isolated from ethanol extract of leaves show antidiabetic and antihyperlipidemic properties[54].

### 3.20. *Ipomoea batatas* (*I. batatas*) (*Convolvulaceae*)

The active ingredients isolated from *I. batatas* showed antidiabetic property and also stimulated immune system[55]. The flavonoids isolated from leaf ameliorate blood glucose level and lipid parameters in alloxan induced diabetic mice at 50–150 mg/kg[56].

### 3.21. *Jatropha curcas* (*J. curcas*) (*Euphorbiaceae*)

The hydro alcoholic and chloroform extracts of *J. curcas* leaves demonstrate significant antidiabetic property at 250 and 500 mg/kg dose dependently in alloxan induced diabetic rats[11,57].

### 3.22. *Lantana camara* (*Verbenaceae*)

Methanol extracts of leaves possess antidiabetic and antihyperlipidemic properties[58]. In addition to this, ethanol extracts possess antidiabetic property in rats[59].

### 3.23. *Mangifera indica* (*M. indica*) (*Anacardiaceae*)

Intraperitoneal administration of aqueous extract of stem bark (50–800 mg/kg) produces significant hypoglycemic effect in streptozotocin induced diabetic rats in a dose dependent manner[60]. The oral administration of peel extract at 200 mg/kg to streptozotocin induced diabetic rats possesses significant antidiabetic and antihyperlipidemic activity[61]. Mangiferin, a polyphenol isolated from *M. indica* significantly prevents progression of diabetic nephropathy and improves renal function in diabetic nephropathy rat model and cultured rat mesangial cells[62].

### 3.24. *Momordica charantia* (*M. charantia*) (*Cucurbitaceae*)

Oral administration of seed extracts at a concentration of 150 mg/kg b.w. for 30 days showed a significant decrease in fasting blood glucose, hepatic and renal thiobarbituric acid reactive substances and hydroperoxides. Also it shows significant increase in reduced glutathione, superoxide dismutase, catalase, glutathione peroxidase and glutathione-S-transferase in the liver and kidney of diabetic rats[63]. Subcutaneous administration of juice and alcoholic extract to alloxan induced diabetic rats causes anti-diabetic, hepato-renal protective and hypolipidemic effect[64]. Bitter fruit attenuates development of diabetes and its complications[65]. The Dihar a polyherbal formulation containing bitter fruit showed significant antidiabetic and antihyperlipidemic activity in streptozotocin induced diabetic rats[66]. Oral administration of freeze dried extract at 50 and 100 mg/kg demonstrates, no activity on plasma glucose/insulin levels, energy expenditure, substrate mixture and appetite scores following an oral glucose load in non-diabetic overweight[67]. The alcalase hydrolysate from *M. charantia* showed stronger hypoglycemic effect[68]. The saponin from aqueous extract of bitter fruit shows significant hypoglycemic activity in hyperglycemic and normal mice at 500 mg/kg[69]. Oral administration of lipid and saponin fractions of fruit possesses significant antidiabetic activity by ameliorating biochemical parameters in db/db mice at 150 mg/kg[70].

### 3.25. *Morus alba* (*M. alba*) (*Moraceae*)

The oral administration (600 mg/kg/day for ten days) of flavonoid rich fractions from alcoholic extract of root bark significantly reduces blood glucose by increasing insulin level and also shows decrease in the lipid peroxides in streptozotocin induced diabetic rats[71]. Arayens *et al*

reported that, the methanolic extract of *M. alba* inhibits glucose diffusion *in vitro*[72]. Oral administration of leaves at 0.5 and 1 g/kg, significantly reduces blood glucose level, also decreases the high blood pressure in streptozotocin induced chronic diabetic rats[73]. The moracin M, steppogenin-4'-O-beta-D-glucoside and mullberroside-A, isolated from root bark show hypoglycemic effect at a dose of 100 mg/kg in alloxan induced diabetic mice[15].

### 3.26. *Mucuna pruriens* (*Fabaceae*)

Oral administration of aqueous extract (100 and 200 mg/kg) normalizes blood glucose level in streptozotocin induced diabetic rats[74]. Also the D-chiro-inositol and its two galacto-derivatives isolated from seeds show hypoglycemic potential[75].

### 3.27. *Ocimum sanctum* (*O. sanctum*) (*Lamiaceae*)

Gupta *et al* isolated three new compounds, *viz.* ocimumosides A, ocimumoside B and ocimarin from leaves of *O. sanctum* which were evaluated for antistress property. Out of these new compounds, ocimumosides A possesses antistress activity by normalizing hyperglycemia, plasma corticosterone, plasma creatine kinase, and adrenal hypertrophy[76]. The hydro alcoholic and chloroform extracts of *O. sanctum* aerial part demonstrate significant antidiabetic property at 250 and 500 mg/kg dose dependently in alloxan induced diabetic rats[10,11]. In addition to this, triterpenoid isolated from hydro alcoholic extracts of *O. sanctum* aerial possesses significant antidiabetic activity at 20 mg/kg in alloxan induced diabetic rats[77].

### 3.28. *Pterocarpus marsupium* (*Fabaceae*)

An aqueous extract of wood shows hypoglycemic activity in alloxan induced diabetic rats at oral dose of 250 mg/kg[78]. The butanol subfraction of alcohol extract of bark exhibits significant antidiabetic activity by ameliorating blood glucose and lipid parameters in alloxan induced diabetic rats[79].

### 3.29. *Punica granatum* (*Punicaceae*)

The oral administration of methanol extract of flowers at 500 mg/kg inhibits glucose loading-induced increase in plasma glucose levels in Zucker diabetic fatty rats[80]. Parmar and Kar, reported that, fruit peel extract normalizes all the adverse changes induced by alloxan mice, revealing the antidiabetic and anti peroxidative potential at 200 mg/kg[61]. In addition to this, oral administration of aqueous extract of flowers (250 and 500 mg/kg) ameliorates blood glucose, lipid parameters and oxidative stresses in streptozotocin induced diabetic rats[81]. Administration of pomegranate seed oil reduces blood glucose level and lipid parameters in mice[82].

### 3.30. *Salacia oblonga* (*S. oblonga*) (*Hippocrateaceae*)

The extract of *S. oblonga* lowers acute glycemia and insulinemia in type-2 diabetic patients after a high-carbohydrate meal[83] and decreases glycemia in healthy subject[84–92].



### 3.31. *Eugenia jambolana* (*E. jambolana*) (*Myrtaceae*)

Oral administration of ethanolic extract of *E. jambolana* seeds (100 mg/kg) in streptozotocin induced diabetic rats causes hypolipidemic effect[93]. The water and ethanolic extracts of the fruit–pulp of *E. jambolana* elicit antihyperglycemic effect. Water extract was found to be more effective than the ethanolic extract in reducing fasting blood glucose and improving blood glucose in glucose tolerance test[94]. Arayne *et al* reported that, the methanolic extract of *E. jambolana* inhibited glucose diffusion *in vitro*[72]. The flavonoid rich extract from *E. jambolana* seeds elicits both hypoglycemic effects by stimulating increase in insulin release *in vitro* from pancreatic islets and antihyperlipidemic effects in streptozotocin induced diabetic rats[95]. Oral administration of ethanolic extract of seeds (200 mg/kg) for 30 days in streptozotocin diabetic rats shows promising antidiabetic effect. In addition to this, seeds possess better ulcer healing effects by promoting defensive or reducing offensive mucosal factors in mild diabetic rats[96]. Furthermore, oral administration of ethyl acetate fractions of *E. jambolana* (200 mg/kg) for 90 days to streptozotocin induced diabetic rats causes optimum antihyperglycemic[97].

### 3.32. *Tinospora cordifolia* (*T. cordifolia*) (*Menispermaceae*)

The extract of *T. cordifolia* stem ameliorates the derangements in lipid metabolism caused by diabetes mellitus in streptozotocin induced diabetic rats[98]. The oral administration of various extracts (hexane, ethyl acetate and methanol) of *T. cordifolia* stem was found to have potent antidiabetic property by reducing blood sugar level in streptozotocin induced diabetic rats at a dose of 250 mg/kg[99]. The polyherbal formulation, Dihar containing eight different herbs *viz.*, *Syzygium cumini*, *Momordica charantia*, *Emblica officinalis*, *Gymnema sylvestre*, *Enicostemma littorale*, *Azadirachta indica*, *T. cordifolia* and *Curcuma longa* significantly reduces level of lipid peroxidation and increases activity of antioxidant enzymes in streptozotocin induced diabetic rats[66]. The ethyl acetate, dichloromethane, chloroform and hexane extracts of *T. cordifolia* stem were evaluated for alpha glucosidase inhibition activity and resulted that the dichloromethane extract was the most effective *i.e.* 100% inhibition of the alpha glycosidase than others[100]. The ethanol extract of *T. cordifolia* demonstrates an androgenic activity[101]. Saponarin isolated from leaf extract of *T. cordifolia* showed hypoglycemic activity at doses of 20–80 mg/kg[102]. The hydro alcoholic and chloroform extracts of *T. cordifolia* stem demonstrates significant antidiabetic property at 250 and 500 mg/kg dose dependently in alloxan induced diabetic rats[10,11].

### 3.33. *Trigonella foenum graecum* (*Fabaceae*)

Eidia *et al* reported that, oral administration of ethanolic extract fenugreek (0.1, 0.25, and 0.5 g/kg for 14 days) shows antidiabetic effect in streptozotocin induced diabetic rats by normalizing level of serum glucose, total cholesterol, triacylglycerol, urea, uric acid, creatinine, aspartate aminotransferase and alanine aminotransferase[103]. A diet controlled diabetic subjects receiving bread incorporating fenugreek (5%) shows remarkable decrease in blood glucose

level[104]. The administration of fiber isolated from fenugreek (4 g or 8 g) to healthy obese subjects causes increased satiety and reduced energy intake[105]. The administration of ethanol extract of fenugreek seeds at different doses (2 g/kg, 1 g/kg, 0.5 g/kg and 0.1 g/kg) causes dose dependent hypoglycemic effect relative to standard antidiabetic drug in alloxan induced diabetic rats[106–109]. Administration of fenugreek seeds ameliorates abnormalities in lipid homeostasis due to its hypolipidemic properties inhibition of fat accumulation and upregulation of LDL receptor[110]. Fenugreek contains an unusual amino acid, 4-hydroxyisoleucine, demonstrated to have insulinotropic and antidiabetic properties in streptozotocin induced rats by altering levels of glucose or liver damage markers significantly[111]. Oral administration of 4-hydroxyisoleucine, an unusual amino acid isolated from fenugreek seeds (50 mg/kg) to db/db mice ameliorates blood glucose level and lipid parameters by enhancing insulin sensitivity and glucose uptake in peripheral tissue[112].

## 4. Conclusion

Most popularly used drugs of modern medicine such as atropine, quinine, artemisinin, digitalis, reserpine, metformin, *etc* have been originating from plant source. About less than 1% of estimated higher plants have been screened pharmacologically for diabetes mellitus. The main undesirable effects of current treatment include hypoglycemia, allergy, gastrointestinal disturbances, heart failure, lactic acidosis, *etc.* which may limit the use of these drugs in diabetes mellitus. It was reported that *M. charantia*, *E. jambolana*, *T. foenum graecum*, *O. sanctum*, *etc.* have shown varying degree of hypoglycemic and antihyperglycemic activity. This review of ethnomedicinal value of these plants may be helpful in the treatment of diabetes.

## Conflict of interest statement

We declare that we have no conflict of interest.

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## References

- [1] Anonymous. *Diabetes Atlas*. 3rd ed. Brussels: International Diabetes Federation; 2006.
- [2] Puranik N, Kammar KF, Devi S. Anti-diabetic activity of *Tinospora cordifolia* (Wild.) in streptozotocin diabetic rats; does it act like sulfonylurea? *Turk J Med Sci* 2010; **40**(2): 265–270.
- [3] Edeoga HO, Okwu DE, Mbaebie BO. Phytochemical constituents of some Nigerian medicinal plants. *Afr J Biotechnol* 2005; **4**(7): 685–688.
- [4] Olasode OA. Why vitiligo in diabetes. *Egypt Dermatol Online J* 2005; **1**(2): 1–6.
- [5] Etuk EU, Bello SO, Isezuo SA, Mohammed BJ. Ethnobotanical

- survey of medicinal plants used for the treatment of diabetes mellitus in the north western region of Nigeria. *Asian J Exp Biol Sci* 2010; **1**(1): 55–59.
- [6] Cooke DW, Plotnick L. Type 1 diabetes mellitus in pediatrics. *Pediatr Rev* 2008; **29**(11): 374–384.
- [7] Riserus U, Willett WC, Hu FB. Dietary fats and prevention of type-2 diabetes. *Prog Lipid Res* 2009; **48**(1): 44–51.
- [8] Wadood N, Nisar M, Rashid A, Wadood A, Nawab G, Khan A. Effect of a compound recipe (medicinal plants) on serum insulin levels of alloxan diabetic rabbits. *J Ayub Med Coll Abbottabad* 2007; **19**(1): 32–38.
- [9] Yasir M, Jain P, Debajyoti, Kharya MD. Hypoglycemic and antihyperglycemic effect of different extracts of *Acacia arabica* lamk bark in normal and alloxan induced diabetic rats. *Int J Phytomed* 2010; **2**: 133–138.
- [10] Patil RN, Patil RY, Ahirwar D. Study of some medicinal plants for antidiabetic activity in alloxan induced diabetes. *Pharmacologyonline* 2010; **1**: 53–60.
- [11] Patil RN, Patil RY, Ahirwar B, Ahirwar D. Evaluation of antidiabetic and related actions of some Indian medicinal plants in diabetic rats. *Asian Pac J Trop Med* 2011; **4**(1): 20–23.
- [12] Sharma B, Sathapathi SK, Roy P. Hypoglycemic and hypolipidemic effect of *Aegle marmelos* (L) leaf extract on streptozotocin induced diabetic mice. *Int J Pharmacol* 2007; **3**(6): 144–152.
- [13] Akbarshah AM, Raod MV, Arumugama S, Kavimanib S, Kadalmanic B, Ahmed ABA. Antidiabetic activity of leaf and callus extracts of *Aegle marmelos* in rabbit. *Sci Asia* 2008; **34**: 317–321.
- [14] Mohammad Y, Mohammad I. Clinical evaluation of antidiabetic activity of *Trigonella* seeds and *Aegle marmelos* leaves. *World Appl Sci J* 2009; **7**(10): 1231–1234.
- [15] Zhang JH, Cheng YS. Studies on the lowering blood sugar substances from agrimony. *Zhong Yao Cai* 2009; **32**(10): 1537–1539.
- [16] El-Demerdash FM, Yousef MI, El-Naga NI. Biochemical study on the hypoglycemic effects of onion and garlic in alloxan-induced diabetic rats. *Food Chem Toxicol* 2005; **43**(1): 57–63.
- [17] Islam MS, Choi H, Loots du T. Effects of dietary onion (*Allium cepa* L.) in a high-fat diet streptozotocin-induced diabetes rodent model. *Ann Nutr Metab* 2008; **53**(1): 6–12.
- [18] Kook S, Kim GH, Choi K. The antidiabetic effect of onion and garlic in experimental diabetic rats: meta-analysis. *J Med Food* 2009; **12**(3): 552–560.
- [19] Asaduzzaman M, Akhtar MA, Islam MA, Khan MRI, Anisuzzaman A, Ahmed M. Evaluation of antidiabetic, antihyperlipidemic and hepatoprotective effects of *Allium sativum* (Linn.) in alloxan induced diabetic rats. *Bangladesh Pharm J* 2010; **13**(1): 28–33.
- [20] Balasubramaniam D, Mitra A, Manjunatha M. Antidiabetic and hypolipidaemic effects of few common plants extract in type 2 diabetic patients at Bengal. *Int J Diabetes Metab* 2010; **18**: 59–65.
- [21] Bokaeian M, Nakhaee A, Moodi B, Farhangi A, Akbarzadeh A. Effects of garlic extract treatment in normal and streptozotocin diabetic rats infected with *Candida albicans*. *Indian J Clin Biochem* 2010; **25**(2): 182–187.
- [22] Mandlaik RV, Deasi SK, Naik SR, Sharma G, Kohli RK. Antidiabetic activity of polyherbal formulation (DRF/AY/5001). *Indian J Exp Biol* 2008; **46**(8): 599–606.
- [23] Mahesar H, Bhutto MA, Khand AA, Narejo NT. Garlic used as an alternative medicine to control diabetic mellitus in alloxan-induced male rabbits. *Pak J Physiol* 2010; **6**(1): 39–41.
- [24] Rajasekaran S, Ravi K, Sivagnanam K, Subramanian S. Beneficial effects of *Aloe vera* leaf gel extract on lipid profile status in rats with streptozotocin diabetes. *Clin Exp Pharmacol Physiol* 2006; **33**: 232–237.
- [25] Rajendran A, Narayanan V, Gnanave I. Evaluation of therapeutic efficacy of *Aloe vera* sap in diabetes and treating wounds and inflammation in animals. *J Appl Sci Res* 2007; **3**(11): 1434–1436.
- [26] Kima K, Kima K, Kwona J, Leea S, Konga H, Imb S, et al. Hypoglycemic and hypolipidemic effects of processed *Aloe vera* gel in a mouse model of non-insulin-dependent diabetes mellitus. *Phytomedicine* 2009; **16**: 856–863.
- [27] Yagi A, Hegazy S, Kabbash A, Abd-El EW. Possible hypoglycemic effect of *Aloe vera* L. high molecular weight fractions on type 2 diabetic patients. *Saudi Pharm J* 2009; **17**: 209–215.
- [28] Perez YY, Ferrer EJ, Zamilpa A, Valencia MH, Aguilar FJA, Tortoriello J, et al. Effect of a polyphenol-rich extract from *Aloe vera* gel on experimentally induced insulin resistance in mice. *Am J Chi Med* 2007; **35**(6): 1037–1046.
- [29] Misawaa E, Tanakaa M, Nomaguchia K, Yamadaa M, Toidaa T, Takaseb M, et al. Administration of phytosterols isolated from *Aloe vera* gel reduce visceral fat mass and improve hyperglycemia in Zucker diabetic fatty (ZDF) rats. *Obes Res Clin Pract* 2008; **2**: 239–245.
- [30] Bhist S, Sisodia SS. Anti-hyperglycemic and antidyslipidemic potential of *Azadirachta indica* leaf extract in streptozotocin-induced diabetes mellitus. *J Pharm Sci Res* 2010; **2**(10): 622–627.
- [31] Chattopadhyay RR, Bandyopadhyay M. Effect of *Azadirachta indica* leaf extract on serum lipid profile changes in normal and streptozotocin induced diabetic rats. *Afr J Biomed Res* 2005; **8**: 101–104.
- [32] Ebong PE, Atangwho IJ, Eyong EU, Egbung GE. The antidiabetic efficacy of combined extracts from two continental plants: *Azadirachta indica* (A. Juss) (neem) and *Vernonia amygdalina* (Del.) (African bitter leaf). *Am J Biochem Biotechnol* 2008; **4**(3): 239–244.
- [33] Atangwho IJ, Ebong PE, Eyong EU, Egbung GE. Combined extracts of *Vernonia amygdalina* and *Azadirachta indica* may substitute insulin requirement in the management of type I diabetes. *Res J Med Med Sci* 2010; **5**(1): 35–39.
- [34] Shetty BV, Arjuman A, Jorapur A, Samanth R, Yadav SK, Valliammai N, et al. Effect of extract of *Benincasa hispida* on oxidative stress in rats with indomethacin induced gastric ulcers. *Indian J Physiol Pharmacol* 2008; **52**(2): 178–182.
- [35] Ninfalia P, Bacchioccaa M, Biagiottia AE, Gioacchinob AMD, Piccolib G, Stocchib V, et al. Characterization and biological activity of the main flavonoids from Swiss Chard (*Beta vulgaris* subspecies *cycla*). *Phytomedicine* 2007; **14**: 216–221.
- [36] Anand P, Murli KY, Tandon V, Chandra R, Murthy PS. Preliminary studies on antihyperglycemic effect of aqueous extract of *Brassica juncea* in streptozotocin induced diabetic rats. *Indian J Exp Biol* 2007; **45**: 696–701.
- [37] Chakrabarti S, Biswas TK, Seal T, Rokeya B, Ali L, Azad K, et al. Antidiabetic activity of *Caesalpinia bonducella* F. in chronic type 2 diabetic model in Long-Evans rats and evaluation of insulin secretagogue property of its fractions on isolated islets. *J Ethnopharmacol* 2005; **97**(1): 117–122.
- [38] Kannur DM, Hukkeri VI, Akki KS. Antidiabetic activity of *Caesalpinia bonducella* seed extracts in rats. *Fitoterapia* 2006; **77**(7–8): 546–549.
- [39] Adaobi CE, Peter AA, Charles CO, Chinwe BO. Experimental evidence for the antidiabetic activity of *Cajanus cajan* leaves in rats. *J Basic Clin Pharm* 2010; **1**(2): 81–84.
- [40] Sharma B, Salunke R, Balomajumder C, Daniel S, Roy P. Anti-diabetic potential of alkaloid rich fraction from *Capparis decidua* on diabetic mice. *J Ethnopharmacol* 2010; **127**(2): 457–462.
- [41] Sebbagh N, Cruciani GC, Quali F, Berthault MF, Rouch C, Sari DC, et al. Comparative effects of *Citrullus colocynthis*, sunflower and olive oil-enriched diet in streptozotocin-induced diabetes in rats. *Diabetes Metab* 2009; **35**(3): 178–184.

- [42] Huseini HF, Darvishzadeh F, Heshmat R, Jafariaraz Z, Raza M, Larijani B. The clinical investigation of *Citrullus colocynthis* (L.) schrad fruit in treatment of type II diabetic patients: a randomized, double blind, placebo-controlled clinical trial. *Phytother Res* 2009; **23**(8): 186–189.
- [43] Mallick C, De D, Ghosh D. Correction of protein metabolic disorders by composite extract of *Musa paradisiaca* and *Coccinia indica* in streptozotocin-induced diabetic albino rat: an approach through the pancreas. *Pancreas* 2009; **38**(3): 322–329.
- [44] Ajay SS. Hypoglycemic activity of *Coccinia indica* (Cucurbitaceae) leaves. *Int J PharmTech Res* 2009; **1**(3): 892–893.
- [45] Balaraman AK, Singh J, Dash S, Maity TK. Antihyperglycemic and hypolipidemic effects of *Melothria maderaspatana* and *Coccinia indica* in streptozotocin induced diabetes in rats. *Saudi Pharm J* 2010; **18**: 173–178.
- [46] Gunjan M, Jana GK, Jha AK, Mishra U. Pharmacognostic and antihyperglycemic study of *Coccinia indica*. *Int J Phytomed* 2010; **2**: 36–40.
- [47] Ahlema S, Khaleda H, Wafaa M, Sofiane B, Mohameda D, Claude MJ, et al. Oral administration of *Eucalyptus globulus* extract reduces the alloxan-induced oxidative stress in rat. *Chem Biol Interact* 2009; **181**: 71–76.
- [48] Gayathri M, Kannabiran K. Antidiabetic and ameliorative potential of *Ficus bengalensis* bark extract in streptozotocin induced diabetic rats. *Indian J Clin Biochem* 2008; **23**(4): 394–400.
- [49] Liu B, Asare-Anane H, Al-Romaiyan A, Huang G, Amie SA, Jones PM, et al. Characterisation of the insulinotropic activity of an aqueous extract of *Gymnema sylvestre* in mouse beta-cells and human islets of Langerhans. *Cell Physiol Biochem* 2009; **23**(1–3): 125–132.
- [50] Mall GK, Mishra PK, Prakash V. Antidiabetic and hypolipidemic activity of *Gymnema sylvestre* in alloxan induced diabetic rats. *Glob J Biotech Biochem* 2009; **4**(1): 37–42.
- [51] Wei JH, Zhen HS, Qiu Q, Chen J, Zhou F. Experimental (corrected) study of hypoglycemic activity of conduritol A of stems of *Gymnema sylvestre*. *Zhongguo Zhong Yao Za Zhi* 2008; **33**(24): 2961–2965.
- [52] Daisy P, Eliza J, Mohamed FKA. A novel dihydroxy gymnemic triacetate isolated from *Gymnema sylvestre* possessing normoglycemic and hypolipidemic activity on STZ-induced diabetic rats. *J Ethnopharmacol* 2009; **126**(2): 339–344.
- [53] Venkatesh S, Thilagavathi J, Shyamsundar D. Anti-diabetic activity of flowers of *Hibiscus rosasinensis*. *Fitoterapia* 2008; **79**: 79–81.
- [54] Moqbel FS, Naik PR, Nazma HM, Selvraj S. Antidiabetic properties of *Hibiscus rosa sinensis* L. leaf extract fractions on non obese diabetic (NOD) mouse. *Indian J Exp Biol* 2011; **49**: 24–29.
- [55] Miyazaki Y, Kusano S, Doi H, Aki O. Effects on immune response of antidiabetic ingredients from white skinned sweet potato (*Ipomoea batatas* L.). *Nutrition* 2005; **21**: 358–362.
- [56] Li F, Li Q, Gao D, Peng Y. The optimal extraction parameters and anti-diabetic activity of flavonoids from *Ipomoea batatas* leaf. *Afr J Tradit Complement Altern Med* 2009; **6**(2): 195–202.
- [57] Patil RN, Patil RY, Ahirwar B, Ahirwar D. Antidiabetic activity of leaves of *Jatropha curcus* L. (Euphorbiaceae) in alloxan induced diabetes rats. *Pharmacologyonline* 2010; **3**: 662–668.
- [58] Ganesh T, Sen T, Thilagam E, Thamotharan G, Loganathan T, Chakraborty R. Pharmacognostic and anti-hyperglycemic evaluation of *Lantana camara* (L.) var. aculeate leaves in alloxan-induced hyperglycemic rats. *Int J Res Pharm Sci* 2010; **1**(3): 247–252.
- [59] Kumar KV, Sharief SD, Rajkumar R, Ilango B, Sukumar E. Antidiabetic potential of *Lantana aculeata* root extract in alloxan-induced diabetic rats. *Int J Phytomed* 2010; **2**: 299–303.
- [60] Ojewole JA. Antiinflammatory, analgesic and hypoglycemic effects of *Mangifera indica* Linn. (Anacardiaceae) stem-bark aqueous extract. *Methods Find Exp Clin Pharmacol* 2005; **27**(8): 547–554.
- [61] Parmar HS, Kar A. Possible amelioration of atherogenic diet induced dyslipidemia, hypothyroidism and hyperglycemia by the peel extracts of *Mangifera indica*, *Cucumis melo* and *Citrullus vulgaris* fruits in rats. *Biofactors* 2008; **33**(1): 13–24.
- [62] Li X, Cui X, Sun X, Li X, Zhu Q, Li W. Mangiferin prevents diabetic nephropathy progression in streptozotocin-induced diabetic rats. *Phytother Res* 2010; **24**(6): 893–899.
- [63] Sathishsekar D, Subramanian S. Antioxidant properties of *Momordica charantia* (bitter melon) seeds on streptozotocin induced diabetic rats. *Asian Pac J Clin Nutr* 2005; **14**(2): 153–158.
- [64] Batran SS, Gengaihi S, Shabrawya OA. Some toxicological studies of *Momordica charantia* L. on albino rats in normal and alloxan diabetic rats. *J Ethnopharmacol* 2006; **108**: 236–242.
- [65] Tiwari AK. Karela: a promising antidiabetic vegetable therapy. *Curr Sci* 2007; **92**: 1697–1701.
- [66] Patel SS, Shah RS, Goyal RK. Antihyperglycemic, antihyperlipidemic and antioxidant effects of DIHAR, a polyherbal ayurvedic formulation in streptozotocin induced diabetic rats. *Indian J Exp Biol* 2009; **47**: 564–570.
- [67] Kasbia GS, Arnason JT, Imbeault P. No effect of acute, single dose oral administration of *Momordica charantia* Linn on glycemia, energy expenditure and appetite: a pilot study in non-diabetic overweight men. *J Ethnopharmacol* 2009; **126**(1): 127–133.
- [68] Yuan X, Gu X, Tang J. Optimization of the production of *Momordica charantia* L. Var. abbreviate Ser. protein hydrolysates with hypoglycemic effect using alcalase. *Food Chem* 2008; **111**: 340–344.
- [69] Han C, Hui Q, Wang Y. Hypoglycaemic activity of saponin fraction extracted from *Momordica charantia* in PEG/salt aqueous two-phase systems. *Nat Prod Res* 2008; **22**(13): 1112–1119.
- [70] Klomann SD, Mueller AS, Pallauf J, Krawinkel MB. Antidiabetic effects of bitter melon extracts in insulin-resistant db/db mice. *Br J Nutr* 2010; **104**(11): 1613–1620.
- [71] Singab AN, El-Beshbishy HA, Yonekawa M, Nomura T, Fukai T. Hypoglycemic effect of Egyptian *Morus alba* root bark extract: effect on diabetes and lipid peroxidation of streptozotocin-induced diabetic rats. *J Ethnopharmacol* 2005; **100**: 333–338.
- [72] Arayne MS, Sultana N, Mirza AZ, Zuberi MH, Siddiqui FA. *In vitro* hypoglycemic activity of methanolic extract of some indigenous plants. *Pak J Pharm Sci* 2007; **20**(4): 268–273.
- [73] Naowaboot J, Pannangpetch P, Kukongviriyapan V, Kukongviriyapan U, Nakmareong S, Itharat A. Mulberry leaf extract restores arterial pressure in streptozotocin-induced chronic diabetic rats. *Nutr Res* 2009; **29**(8): 602–608.
- [74] Bhaskar A, Vidhya VG, Ramya M. Hypoglycemic effect of *Mucuna pruriens* seed extract on normal and streptozotocin-diabetic rats. *Fitoterapia* 2008; **79**: 539–543.
- [75] Donati D, Lampariello LR, Pagani R, Guerranti R, Cinci G, Marinello E. Antidiabetic oligocyclitols in seeds of *Mucuna pruriens*. *Phytother Res* 2005; **19**(12): 1057–1060.
- [76] Gupta P, Yadav DK, Siripurapu KB, Palit G, Maurya R. Constituents of *Ocimum sanctum* with antistress activity. *J Nat Prod* 2007; **70**(9): 1410–1416.
- [77] Patil RN, Patil RY, Ahirwar B, Ahirwar D. Isolation and characterization of ant-diabetic component (bioactivity-guided fractionation) from *Ocimum sanctum* L. (Lamiaceae) aerial part. *Asian Pac J Trop Med* 2011; **4**(4): 278–282.
- [78] Mukhtar HM, Ansari SH, Ali M, Bhat ZA, Naved T. Effect of aqueous extract of *Pterocarpus marsupium* wood on alloxan-induced diabetic rats. *Pharmazie* 2005; **60**(6): 478–479.
- [79] Dhanabal SP, Kokate CK, Ramanathan M, Kumar EP, Suresh



- B. Hypoglycaemic activity of *Pterocarpus marsupium* Roxb. *Phytother Res* 2006; **20**(1): 4–8.
- [80] Huang THW, Peng G, Kota BP, Li G, Yamahara QJ, Roufogalis BD, et al. Anti-diabetic action of *Punica granatum* flower extract: activation of PPAR- $\gamma$  and identification of an active component. *Toxicol Appl Pharmacol* 2005; **207**: 160–169.
- [81] Bagri P, Ali M, Aeri V, Bhowmik M, Sultana S. Antidiabetic effect of *Punica granatum* flowers: effect on hyperlipidemia, pancreatic cells lipid peroxidation and antioxidant enzymes in experimental diabetes. *Food Chem Toxicol* 2009; **47**(1): 50–54.
- [82] McFarlin BK, Strohacker KA, Kuehl ML. Pomegranate seed oil consumption during a period of high-fat feeding reduces weight gain and reduces type 2 diabetes risk in CD-1 mice. *Br J Nutr* 2009; **2**(1): 54–59.
- [83] Williams JA, Choe YS, Noss MJ, Baumgartner CJ, Mustad VA. Extract of *Salacia oblonga* lowers acute glycemia in patients with type 2 diabetes. *Am J Clin Nutr* 2007; **86**(1): 124–130.
- [84] Collene AL, Hertzler SR, Williams JA, Wolf BW. Effects of a nutritional supplement containing *Salacia oblonga* extract and insulinogenic amino acids on postprandial glycemia, insulinemia, and breath hydrogen responses in healthy adults. *Nutrition* 2005; **21**: 848–854.
- [85] Kumar S, Kumar V, Prakash Om. Antidiabetic and anti-lipemic effects of *Cassia siamea* leaves extract in streptozotocin induced diabetic rats. *Asian Pac J Trop Med* 2010; **3**(11): 871–873.
- [86] Ramachandran S, Rajasekaran A, Manisenthil Kumar KT. Antidiabetic, antihyperlipidemic and antioxidant potential of methanol extract of *Tectona grandis* flowers in streptozotocin induced diabetic rats. *Asian Pac J Trop Med* 2011; **4**(8): 624–631.
- [87] Kumar S, Kumar V, Prakash Om. Antidiabetic, hypolipidemic and histopathological analysis of *Dillenia indica* (L.) leaves extract on alloxan induced diabetic rats. *Asian Pac J Trop Med* 2011; **4**(5): 347–352.
- [88] Guan T, Qian YS, Huang MH, Huang LF, Tang XZ, Li YM, et al. Neuroprotection of maslinic acid, a novel glycogen phosphorylase inhibitor, in type 2 diabetic rats. *Chin J Nat Med* 2010; **8**(4): 293–297.
- [89] Chen L, Ma XB, Liang YH, Pei SC, Feng YP, Wei M. Effects of persimmon leaf total flavonoid on enzyme of lipoprotein metabolism and antioxidation in hyperlipidemia rats. *Chin J Nat Med* 2011; **9**(1): 74–77.
- [90] Wang D, Tang W, Yang GM, Cai BC. Anti-inflammatory, antioxidant and cytotoxic activities of flavonoids from *Oxytropis falcata* Bunge. *Chin J Nat Med* 2011; **8**(6): 461–465.
- [91] Hong-Lan WANG, Wei-Feng YAO, Dan-Ni ZHU, Yu-Zhu HU. Chemical fingerprinting by HPLC–DAD–ELSD and principal component analysis of *Polygala japonica* from different locations in China. *Chin J Nat Med* 2011; **8**(5): 343–348.
- [92] Li SQ, Su ZH, Peng JB, Zou ZM, Yu CY. *In vitro* and *in vivo* antioxidant effects and the possible relationship between the antidepressant efficacy of traditional Chinese medicine formulation Chaihu Shugan San. *Chin J Nat Med* 2011; **8**(5): 353–361.
- [93] Ravi K, Rajasekaran S, Subramanian S. Antihyperlipidemic effect of *Eugenia jambolana* seed kernel on streptozotocin-induced diabetes in rats. *Food Chem Toxicol* 2005; **43**(9): 1433–1439.
- [94] Sharma SB, Nasir A, Prabhu KM, Murthy PS. Antihyperglycemic effect of the fruit–pulp of *Eugenia jambolana* in experimental diabetes mellitus. *J Ethnopharmacol* 2006; **104**(3): 367–373.
- [95] Sharma B, Balomajumder C, Roy P. Hypoglycemic and hypolipidemic effects of flavonoid rich extract from *Eugenia jambolana* seeds on streptozotocin induced diabetic rats. *Food Chem Toxicol* 2008; **46**(7): 2376–2383.
- [96] Chaturvedi A, Bhawani G, Agarwal PK, Goel S, Singh A, Goel RK. Antidiabetic and antiulcer effects of extract of *Eugenia jambolana* seed in mild diabetic rats: study on gastric mucosal offensive acid–pepsin secretion. *Indian J Physiol Pharmacol* 2009; **53**(2): 137–146.
- [97] Panda DK, Ghosh D, Bhat B, Talwar SK, Jaggi M, Mukherjee R. Diabetic therapeutic effects of ethyl acetate fraction from the roots of *Musa paradisiaca* and seeds of *Eugenia jambolana* in streptozotocin-induced male diabetic rats. *Methods Find Exp Clin Pharmacol* 2009; **31**(9): 571–584.
- [98] Nagaraja PK, Kammar KF, Sheela DR. Efficacy of *Tinospora cordifolia* (Willd.) extracts on blood lipid profile in streptozotocin diabetic rats. Is it beneficial to the heart? *Biomed Res* 2008; **19**(2): 92–96.
- [99] Rajalakshmi M, Eliza J, Priya CE, Nirmal A, Daisy P. Anti diabetic properties of *Tinospora cordifolia* stem extracts on streptozotocin induced diabetic rats. *Afr J Pharm Pharmacol* 2009; **3**(5): 171–180.
- [100] Chougale AD, Ghadyale VA, Panaskar SN, Arvindekar AU. Alpha glucosidase inhibition by stem extract of *Tinospora cordifolia*. *J Enzyme Inhib Med Chem* 2009; **24**(4): 998–1001.
- [101] Kapur P, Pereira BM, Wuttke W, Jarry H. Androgenic action of *Tinospora cordifolia* ethanolic extract in prostate cancer cell line LNCaP. *Phytomedicine* 2009; **16**(6–7): 679–682.
- [102] Sengupta S, Mukherjee A, Gosawami R, Basu S. Hypoglycemic activity of the antioxidant saponarin, characterized as alpha-glucosidase inhibitor present in *Tinospora cordifolia*. *J Enzyme Inhib Med Chem* 2009; **24**(3): 684–690.
- [103] Eidia A, Eidib M, Sokhteha M. Effect of fenugreek (*Trigonella foenum-graecum* L) seeds on serum parameters in normal and streptozotocin-induced diabetic rats. *Nutr Res* 2007; **27**: 728–733.
- [104] Lasso JN, Holliday DL, Finley JW, Martin RJ, Rood JC, Yu Y, et al. Fenugreek bread: a treatment for diabetes mellitus. *J Med Food* 2009; **12**(5): 1046–1049.
- [105] Mathern JR, Raatz SK, Thomas W, Slavin JL. Antihyperglycemic effect of *Trigonella foenum-graecum* (fenugreek) seed extract in alloxan-induced diabetic rats and its use in diabetes mellitus: a brief qualitative phytochemical and acute toxicity test on the extract. *Phytother Res* 2009; **23**(11): 1543–1548.
- [106] Mathern JR, Raatz SK, Thomas W, Slavin JL. Effect of fenugreek fiber on satiety, blood glucose and insulin response and energy intake in obese subjects. *Phytother Res* 2009; **23**(11): 1543–1548.
- [107] Tewari V, Tewari A, Bhardwaj N. Histological and histochemical changes in placenta of diabetic pregnant females and its comparison with normal placenta. *Asian Pac J Trop Dis* 2011; **1**(1): 1–4.
- [108] Arjunan I, Gopinath D, Murthy NS. Role of informal care providers in home based long term care in diabetes mellitus at Kaiwara Primary Health Center area, Karnataka, India. *Asian Pac J Trop Dis* 2011; **1**(2): 127–130.
- [109] Idogun ES, Kasia BE. Assessment of microalbuminuria and glycated hemoglobin in type 2 diabetes mellitus complications. *Asian Pac J Trop Dis* 2011; **1**(3): 203–206.
- [110] Vijayakumar MV, Pandey V, Mishra GC, Bhat MK. Hypolipidemic effect of fenugreek seeds is mediated through inhibition of fat accumulation and upregulation of LDL receptor. *Obesity* 2010; **18**(4): 667–674.
- [111] Haeri MR, Izaddoost M, Ardekani MR, Nobar MR, White KN. The effect of fenugreek 4-hydroxyisoleucine on liver function biomarkers and glucose in diabetic and fructose-fed rats. *Phytother Res* 2009; **23**(1): 61–64.
- [112] Singh A, Singh K, Saxena A. Hypoglycemic activity of different extract of various plants. *Int J Res Ayu Pharm* 2010; **1**(1): 212–224.