Pharmacological and Phytochemical Portrayal of Dicotyledonous Medicinal Plants of Jammu and Kashmir abound with Antidiabetic Potential

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ABSTRACT

Diabetes mellitus is the fourth prime cause of death and is now emerging as an epidemic throughout the globe. India is having the highest number of diabetics in the world and by the year 2025 it is expected to swell up to 57.2 million. Herbal drugs is the oldest known healthcare available to mankind, enlisted in Ayurvedic literature since the time of Charaka and Sushruta (6th century BC), naturopathic, homeopathic and other medicine systems obtained from natural sources which not only are safe, cost effective but are also easily accessible. The aim of the present investigation was to document various therapeutic plants with antidiabetic activity growing in the state of Jammu and Kashmir, India. There are about 41 plant species described in this review representing 40 genera belonging to 29 families of dicotyledonous angiosperms which demonstrate the importance of herbal plants in the therapy of Diabetes mellitus, principally in Jammu and Kashmir (India) where knowledge of these plants with antidiabetic potential and anti-hyperglycemic effects is wanting. More preclinical research is necessary for the investigation of antidiabetic potential of these herbs for the benefit of humanity.

Key words: Diabetes mellitus, antidiabetic activity, dicotyledonous angiosperms, Jammu and Kashmir

INTRODUCTION

Diabetes mellitus is a metabolic disorder portrayed by chronic hyperglycemia, metabolic riots of carbohydrate, fat and protein, finally resulting in defects in insulin secretion, insulin action, or both [1]. Or in simpler words, body cannot generate ample insulin or cannot exploit insulin effectually [2]. Over 347 million people are diabetic globally [3], and its pervasiveness has ascended from 2.4% to 6.4% in preceding 15 years [4] while by the year 2030, 366 million people will be affected [5]. Almost 80% Diabetes related deaths crop up in the low and middle-income countries [6] [7]. In 2005, 1.1 million people died from this disease. According to the World Health Organization [8], diabetes will be the 7th principal reason of death in 2030.

Majorly diabetes has amplified owing to ageing populations, rising urbanization, dietary changes, reduced physical activity, detrimental behaviors [9], obesity and hereditary factors [10]. Hyperglycemic condition leads to enhanced glycosylation, thus causing biochemical and morphological abnormalities owing to altered protein structure and development of neuropathy, retinopathy and cardiomyopathy [11]. Currently accessible therapies for diabetes management include insulin and a variety of oral antidiabetic agents for example, sulfonylureas, biguanides and glinides [12].
Antidiabetic drugs as mono-therapy or permutations can be used to achieve better glycemic control, but with side effects [13][14] and not any antidiabetic drug devoid of side effects can give an enduring glycemic control [15]. According to world ethno botanical information reports, approximately 800 plants own antidiabetic potential [16]. World health organization [17] has recommended the evaluations of ethno botanical treatment for diabetes, as it is effectual, easily available, safe, cheaper- only affordable resource of healthcare for world’s underprivileged patients, consumed raw [18] and is considered to be a precious resource for the exploration of hypoglycemic agents [19], [20] with a character in diabetes management [21-23]. WHO has listed 21,000 plants as medicinal all over the globe. India-the botanical garden of the world, is the largest producer of medicinal herbs with 2500 species out of which 150 species are used commercially on a huge scale [24-27]. This review endows with a detailed description of some dicotyledonous angiospermic medicinal plants (Figure 1) with anti-diabetic activity, especially from the state of Jammu and Kashmir, India:

1. *Achyranthes aspera*  
*(Family: Amaranthaceae)*  
*Local Name: Rough Chaff Bush, Purkanda, Chirchita*  
The aqueous and methanol extracts of *A. aspera* decreases blood glucose levels and its powder produces a significant dose-related hypoglycemic effect in normal and alloxan diabetic rabbits, possibly by providing elements like calcium, zinc, magnesium, manganese and copper to the beta-cells [28]. *A. aspera* extracts show anti-hyperglycemic activity in alloxan-treated mice possibly mediated by reduced oxidative stress [29].

2. *Aralia cachemirica*  
*(Family: Araliaceae)*  
*Local Name: Aralia, Khoree*  
Aralia is endemic to the NW Himalayas. The aqueous and alcoholic extracts of the roots of *Aralia cachemirica* at a dose of 250 mg/kg showed statistically momentous hypoglycemic activity in glucose loaded animals, however, no effect was observed in normal fasted rats [30].

3. *Artemesia absinthium*  
*(Family: Compositae, Asteraceae)*  
*Local Name: Sweet Sagewort, Tethwan, Worm Wood*  
The different doses (100, 250 and 500 mg/kg) of *Artemesia absinthium* on oral administered for tenure of 6 weeks showed hypoglycemic activity in normal and STZ induced diabetic rats, which could be compared to Metformin (10 mg/kg). In *Artemisia absinthium* treated diabetic rat, the high-density lipoprotein (HDL) levels, liver glycogen level, food intake and bodyweight and glucose tolerance increased whereas the elevated triglycerides, total cholesterol, ALT, AST, urea and creatinine levels were significantly reduced. Histopathological examination showed that the continuous treatment with *Artemisia absinthium* improved the repair of tissues after STZ induced injury, concluding that *Artemisia absinthium* can be an effective source of anti diabetic phytodrugs [31].

4. *Bauhinia variegata*  
*(Family: Fabaceae)*  
*Local Name: Orchid, Kachnara*  
The leaves of the many *Bauhinia* species are used in antidiabetic treatments by many populations of the world. In India, stem bark of *B. variegata* is used as an antidiabetic in the Ayurvedic medicine system. The ethanolic extract of *B. variegata* and its major constituent, roseoside, showed enhanced insulin release from the beta-cell lines INS-I [32].

All normoglycaemic and hyperglycemic rats orally were subjected to *Bauhinia variegata* bark extract (BVBE- 200 and 400mg/kg) or metformin (500mg/kg) as a reference standard for 7 days which drastically reduced the blood glucose levels in hyperglycemic animals. Hyperglycemia was induced in fasted rats by single intravenous dose of alloxan monohydrate. The antihyperglycaemic effect of BVBE was comparable to metformin, however, the precise mechanism of the hypoglycemic action of BVBE is not clear, but it can be speculated that the extract may be performing like metformin [33].

5. *Berberis aristata*  
*(Family: Berberidaceae)*  
*Local Name: Indian Berberry, Kashmiri Kawdach*
Anti-hyperglycemic activity ethanol extract of root of *Berberis aristata* was studied in alloxan-induced diabetic rats wherein dosages of 71.42 and 100mg/kg body weight showed a significant (P<0.01) reduction of serum glucose level on 15th day than diabetics. Cholesterol and triglycerides level were increased very significantly (p<0.01), in diabetic animal when compared with normal control group. In oral glucose tolerance test, glucose tolerance showed increase [34].

6. *Boerhaavia diffusa*  
(Family: Nyctaginaceae)  
Local Name: Horse Purslane, Hogwood, It-Sit, Santhii  
The *Boerhaavia diffusa* leaves show antidiabetic activity both in aqueous and chloroform extracts. The chloroform leaf extracts decrease blood glucose level and increase insulin sensitivity in streptozotocin induced diabetic rats [35]. The aqueous leaf extracts with hypoglycemic and antihyperglycemic activity increases plasma insulin levels and glucose tolerance [36].

7. *Bombax ceiba*  
(Family: Malvaceae)  
Local Name: Red Silk Cotton tree, Kapok Tree, Simbhali  
Shamimin, a C-flavonol glucoside isolated from *Bombax ceiba* leaf extract showed significant hypotensive and hypoglycaemic activity at 500 mg/kg and was found to be safe in Sprague-Dawley rats [37]. *Bombax ceiba* bark extract contains triterpenoid compounds which showed hypoglycemic and hypolipidemic potential in normal and streptozotocin-induced diabetic rats on oral administration with a dose of 600 mg/kg of *B. ceiba* extract for 21 days and also reduced the total cholesterol and triglyceride level in severely diabetic rats [38].

8. *Bougainvillea spectabilis*  
(Family: Nyctaginaceae)  
Local Name: Paper Flower, Boganbilli, Bouganvilas  
The ethanolic leaf extract of *Bougainvillea spectabilis* streptozotocin induced type 1 diabetic albino rats may be due to elevated insulin sensitivity and glucose uptake by enhanced glycogenesis in liver [35]. *B. spectabilis* stem bark extract exhibited considerable hypoglycemic activity and was found to be 22.2% more potent than standard oral hypoglycemic drug, glibenclamide 0.2 mg/kg. The stem bark extract therapy to alloxan induced diabetic rats up to a week upturned the permanent hyperglycemia [39]. Alcoholic extract of leaves of *Bougainvillea spectabilis* leaves have excellent lipid lowering potentiality [40].

9. *Brassica nigra*  
(Family: Brassicaceae, Cruciferae)  
Local Name: Black Mustard, Kali Aur, Kali Rayi  
The aqueous extract of *Brassica nigra* when administered orally for two months in diabetic rats’ leads release of insulin from pancreas resulting in deceased serum glucose level [41]. Aqueous extract of *Brassica nigra* (L.) seeds lead to anti-hyperglycemic effect in streptozotocin-induced diabetic rats and reduce the levels of fasting serum glucose, glycosylated hemoglobin (HbA1c) and serum lipids in diabetic mammals after a month [42].

10. *Brassica juncea*  
(Family: Brassicaceae, Cruciferae)  
Local Name: Indian Mustard, Saetri Sarsu, Rai  
Hypoglycemic activity of *Brassica juncea* (seeds) aqueous extract at varied dosages of 250, 350 and 450mg/kg body weight was evaluated on streptozotocin induced diabetic male albino rats wherein the serum insulin levels showed significant depletion in both short term and long term diabetic animals, in comparison to normal animals [43]. The methanol extract of *Brassica juncea* leaves exhibited dose-dependent and significant anti-hyperglycemic activity in glucose-induced hyperglycemic mice. at the lowest dose of the extract (50 mg/kg body weight) serum glucose levels were lowered by 27.07% and with the dose of 200 mg extract/kg body weight maximum serum glucose lowering effect (46.79%) was achieved while the antidiabetic drug, glibenclamide (10 mg/kg body weight) lowered serum glucose level by 73.40% [44].

11. *Bryophyllum pinnatum* Kurz  
(Family: Crassulaceae)  
Local Name: Jakh Me Hayat, Air Plant, Miracle-Leaf
The anti-diabetic effect of *Bryophyllum pinnatum* plant extract caused significant reductions in the blood glucose levels of the fasted normal and fasted STZ-treated diabetic rats [45]. The aqueous extract of *Bryophyllum pinnatum* leaves on administration in diabetic rats, showed a significant drop in the BGL close to normal blood glucose level in 120 minutes. The aqueous extract and glibenclamide mixture lead to a more drop in BGL suggesting activity of existing drugs (glibenclamide) could be improved with aqueous extract of *Bryophyllum pinnatum* leaves having anti-diabetic properties [46].

12. *Catharanthus roseus*  
(Family: Apocyanaceae)  
Local Name: Vinca Periwinkle, Sadabahar  
The hot water decoction of the plant or its leaves is used as anti diabetic in subtropical and tropical zones [47]. The alcoholic extract of *Catharanthus roseus* leaves showed distinct reduction of glycaemia in control and STZ induced diabetic rats, comparable with tolbutamide [48-51] and showed improvement in parameters of body weight, lipid profile, regeneration of B-cells of pancreas. The regeneration of B-cells of pancreas may be a feasible mechanism of anti-diabetic activity [50]. The methanol leaf extract affects carbohydrate metabolism due to augmented insulin secretion or prevention of harm caused by oxygen free radicals [35] and enhanced glucose consumption [52].

13. *Citrullus colocynthis*  
(Family: Cucurbitaceae)  
Local Name: Duhana, Tarbooz  
The aqueous [53] alcoholic crude [54] and purified extract and beta-pyrazol—alanine (free amino acid derivative in seeds) of *Citrullus colocynthis* induce insulin secretion in islets and pancreas of rats [55] and decrease plasma glucose levels in alloxan induced diabetic rats. It was also confirmed by immunohistochemistry procedures that the amount of insulin was greater in beta cells of Islets of Langerhans in *Citrullus colocynthis* treated alloxan induced diabetic rats than normal rats [56].

14. *Coriandrum sativum* L  
(Family: Apiaceae, Umbelliferae)  
Local Name: Coriander, Dhaniya  
The ethanol extract (200 and 250 mg/kg, i.p) of *Coriandrum sativum* L. seeds revealed a considerable reduction in serum glucose in STZ induced diabetic rats and increased insulin release from the beta cells of the pancreas. The STZ lead to reduction in number of beta cell with insulin secretary activity in STZ induced diabetic rats; however, coriander seed extract (200 mg/kg) treatment enhanced the activity of the beta cells than in diabetic control rats [57].

15. *Cucumis sativus*  
(Family: Cucurbitaceae)  
Local Name: Cucumber, Kheera  
The different doses (200 and 400 mg/kg body weight) of powder fruit of *Cucumis sativus* ethanol extract were showed considerable antidiabetic effects in STZ induced rats comparative to the standard drug and lowered the increased cholesterol and LDL level, thus acting both as antidiabetic and antihyperlipidemic [58].

16. *Daucus carota*  
(Family: Apiaceae, Umbelliferae)  
Local Name: Carrot, Gajar  
*Daucus carota* seeds extract possesses anti-oxidant activity which has beneficial effects in *Diabetes mellitus*. Administration of 100, 200 and 300 mg/kg doses of *Daucus carota* seed methanolic extract and glibenclamide for 6 days significantly decreased serum glucose levels, however, only 300 mg/kg of the extract as well as glibenclamide significantly increased insulin serum levels in type I diabetic male rats and also showed hypoglycemic effect by increasing insulin secretion and improvement of the pancreas. Secondly, the male Swiss mice were orally loaded with glucose after the oral loading with 80% ethanol extracts of *Daucus carota*, the extract showed improvement in the glucose tolerance [59].

17. *Eucalyptus globulus*  
(Family: Myrtaceae)  
Local Name: Anukarpoor
The aqueous extracts of *Eucalyptus globules* increase insulin secretion from clonal pancreatic beta cell lines and glucose utilization in mouse abdominal muscles [53]. Eucalyptus alcoholic extract oral administration decreased significantly the serum glucose levels, and increased serum insulin in diabetic but not in normal rats (p<0.05). The hypoglycemic effect of the extract was analogous to that observed through glibenclamide [60].

18. *Ficus bengalensis*  
(Family: Moraceae)  
Local Name: Banyan Tree, Boodh, Badoye  
*Ficus bengalensis* extract leads to elevated serum insulin content in normoglycemic and diabetic rats because of the inhibited insulinase activity from liver and kidneys [53], [55]. The bark of *Ficus bengalensis* contains dimethoxy derivative of leucocyanidin 3-O-beta-D-galactosyl-celllobioside (250mg/kg) having insulin mimetic property [36] causes blood sugar lowering effect, hypolipidemic and serum insulin raising effects in moderately diabetic rats. The dimethoxy ether of leucopelargonidin-3-O-alpha-L-rhamnoside (100mg/kg) produces hypoglycemic and insulin mimetic activity in healthy and alloxan induced diabetic dogs during a period of 2 hours [55].

19. *Hibiscus rosa sinensis*  
(Family: Malvaceae)  
Local Name: Shoe Flower, Jasund, Urhul, Gudhal  
The *Hibiscus rosa sinensis* extract shows antidiabetic (hypoglycemic and hypolipidemic) and antioxidant activity in STZ induced diabetic rats. The hypoglycemic activity was investigated with different dosages (125, 250 and500 mg/kg b.w) by evaluating various biochemical parameters. Among the three doses, 250 mg/kg ethanol extract of *Hibiscus rosa sinensis* showed best results and lead to increased levels of blood glucose because of insulin release by stimulation of pancreatic beta cells [18], carbohydrate metabolizing enzymes, TBARS, enzymatic and non-enzymatic antioxidants and lipid profiles in diabetic rats than control rats [61].

20. *Ipomoea batatas*  
(Family: Convolvulaceae)  
Local Name: Sweet Potato, Shakarkandi  
Oral administration of *Ipomoea batatas* herb lessens hyperinsulinemia in Zucker fatty rats’ upto 50% after 8 weeks. After 7 weeks of treatment, inhibition of blood glucose level after glucose loading, regranulation of pancreatic beta cells and decline in insulin resistance was observed [62].

21. *Juglans regia* L.  
(Family: Juglandaceae)  
Local Name: English walnut, Akhroot, Dhoon  
The key bioactive molecule found in green and fresh walnuts is a toxic compound Juglone (5-hydroxy-1, 4-naphthoquinone) [63]. *J. regia* extracts resulted in a huge decline in blood glucose, glycosylated hemoglobin, LDL, triglyceride and total cholesterol and boost in insulin and HDL level in experimental models [64]. *J. regia* aqueous extract influences blood levels of glucose, insulin and HbA1C in type 2 diabetic patients and drastically reduced serum fasting HbA1C and blood glucose levels and enhanced the insulin levels in human patients [65]. *Juglans regia* leaf extract (100mg) daily two times for three months improves lipid profile and glycemic control in type II diabetic patients devoid of any concrete side effects [66].

22. *Lantana camara*  
(Family: Verbenaceae)  
Local Name: Yellow Sage, Panjphulii, Mushk Jadi  
This hepatotoxic aromatic shrub is mentioned in Ayurveda for treatment of various disorders. *Lantana camara* leaf juice (1500mg/kg/day) administration for 14 days showed considerable hypoglycemic effect in rats [67].

23. *Mangifera indica*  
(Family: Anacardiaceae)  
Local Name: Mango, Aam, Ambhe  
Mango peel contains polyphenols, carotenoids, dietary fibre and bioactive compounds and is antioxidant [68] in nature. In rat models urine sugar, urine volume, fasting blood glucose, total cholesterol, triglycerides and low density lipoprotein showed increase and decrease in high density lipoprotein; however, the diabetic rats when fed with diet supplemented with mango peel at 5% and 10% levels demonstrated increased antioxidant enzyme...
activities, glomerular filtration rate, microalbuminuria levels and decreased lipid peroxidation in plasma, kidney and liver compared to untreated diabetic rats [69]. The antidiabetic activity could be due to reduction in intestinal absorption of glucose [70].

24. *Marrubium vulgare*  
(Family: Lamiaceae, Labiateae)  
Local Name: Gand Soi  
Some studies reported the anti-oxidant effect of the *Marrubium vulgare* methanolic extract due to its flavonoid content and thus can have protective, antihyperglycemic and antidyslipidemic effect. The single oral dose of 500mg/kg day of *M. vulgare* for 28 days radically reduced the blood glucose level and enhances the plasma insulin and tissue glycogen contents. The antidyslipidemic effect showed major decline in plasma total cholesterol (TC), triglycerides (TG), and low density lipoprotein-cholesterol (LDL-C), and increase in cardio-protective lipid high density lipoprotein (HDL-C) [71].

25. *Momordica charantia*  
(Family: Cucurbitaceae)  
Local Name: Bitter gourd, Karela  
*Momordica charantia* is used in Ayurveda for treatment of diabetes mellitus. The extract powders of the fresh and dried whole fruits have blood glucose lowering effect comparable to that of glibenclamide, a known synthetic drug and thus appear to be a safe alternative in reducing blood glucose. The plant contains insulin mimetic activity due to momordicin, charantin phytochemicals and other galactose -binding lectin and insulin- like proteins [72] [73]. Charantin leads to delayed hypoglycemia in changeable doses in normal fasting rabbits, the fall being regular and stable for 4 h and then recovering gradually. It is more vigorous than comparable doses of tolbutamide and may act at pancreatic as well as extra pancreatic site [74] . The aqueous extract of unripe fruits of bitter gourd moderately kindles liberation of insulin from isolated beta cells of obese-hyperglycemic mice because of perturbations of membrane functions [18]. It further recovers partially destroyed pancreatic cells thereby stimulates insulin secretion [75].

26. *Morus alba*  
(Family: Moraceae)  
Local Name: Mulberry, Tul  
The effect of the methanol and aqueous extracts of *Morus alba* leaves showed considerable reduction in the blood glucose levels in STZ induced diabetic rats. The methanolic extract (18.88 %) showed better antidiabetic activity than aqueous extract (9.91 %) in diabetic albino rats [76].

27. *Mucuna pruriens*  
(Family: Leguminosae, Fabaceae)  
Local Name: Co-witch Plant, Horse Eye Bean, Jajholi, Gajal Bel  
The *Mucuna pruriens* seeds bear glucose lowering activity at various dosages of 0.5, 1, 2g/kg, p.oin normal and 1 and 2g/kg in alloxan induced diabetic rabbits, because of insulin release or insulin like action due to existence of trace elements like manganese and zinc in the powdered seeds of *Mucuna pruriens* plant [18], [36].

(Family: Rutaceae)  
Local Name: Curry Leaf Tree, Curry Pata, Kadi Patre, Drunkal  
The aqueous extract of *M. koenigii* leaves produced hypoglycemic effect both in normal and alloxan diabetic rats [77]. When the plant was fed as oral diet to normal rats for 60 days, the plant’s hypoglycemic activity enhanced hepatic glycogen concentration [43]. Further, feeding of different doses of *M. koenigii* leaves to diabetic rats may control type I diabetes [78], represses blood glucose level and enhances carbohydrate metabolism [79].

29. *Nelumbo nucifera* Gaertn.  
(Family: Nymphaeaceae, Nelumbonaceae)  
Local Name: Lotus, Kamal, Pamposh  
The powdered, aqueous and alcoholic extracts and sun-dried flowers of *Nelumbo nucifera* produced significant hypoglycemia in fasting normal albino rabbits [80]. In streptozotocin induced animals, the rhizome and flower extracts showed significant anti diabetic property [81]. *Nelumbo nucifera* flower extract (NNFE) at a dose of 250
mg/kg significantly (p<0.05) decreased the levels of fasting blood glucose (FBG), total cholesterol (TC), triglycerides (TG), low density lipoprotein (LDL), and blood urea nitrogen (BUN) but increased high density lipoprotein (HDL) in the NNFE- treated diabetic rats compared to diabetic controls indicating that NNFE possesses hypoglycemic and hypolipidemic activities [82]. The oral administration of seed ash of *Nelumbo nucifera* at a concentration of 200 mg/kg body weight for 30 days in streptozotocin-induced diabetic rats demonstrated significant hypoglycemic activity. The presence of trace elements in appreciable amounts in the seeds may play a direct or indirect role on insulin secretion or its action in a synergetic mode. The hypoglycemic activity of the ash was comparable with glyclazide [83].

### 30. *Nymphaea stellata* Willd.
(Family: Nymphaeaceae)
Local Name: Blue Water Lily, Nippa
Nymphayol, a steroid isolated from the flowers of *Nymphaea stellata* has been scientifically proved to enhance the antioxidant defense against the reactive oxygen species (ROS) produced under hyperglycemic states, protect the pancreatic β-cells against loss and leads to stimulation of insulin secretion in the β-cells [84]. The defatted ethanolic leaf extract at a dose of 100 and 200 mg/kg decreased the hyperglycemia, cholesterol and triglycerides levels [85]. The flower extract at a dose of 300 mg/kg caused significant drop in the blood glucose level (45%) 4 hours after administration in diabetic rats. The hydro alcoholic extract exhibited a dose-dependent effect [86].

### 31. *Ocimum sanctum* (Family: Lamiaceae, Labiatae)
Local Name: Holy Basil, Sacred Basil, Tulsi
The Tulsi is reported to be antioxidant, antibacterial, antifungal, antiviral, antiasthemitic, antistress, antitumor, antimutagenic and immunostimulant in nature. The Oral administration of leaf aqueous extract (200 mg/kg) for 30 days leads to major reduction in blood sugar level in both normal and alloxan induced diabetic rats. The hypoglycemic and hypolipidemic effects of tulsi is signified by the considerable reduction in fasting blood glucose, uronic acid, total amino acids, total cholesterol, triglyceride and total lipid in diabetic rats. The Renal glycogen content enhances 10 fold whereas skeletal muscle and hepatic glycogen levels decline by 68 and 75% respectively in diabetic rats in comparison to control [87].

### 32. *Prunella vulgaris* (Family: Labiatae, Lamiaceae)
Local Name: Carpenter’s Grass, Kalwuth, Kala Pethoo
Jiangtangsu which is isolated from *Prunella vulgaris* has blood sugar lowering effect through recovery of pancreatic islets for release of insulin [75].

### 33. *Psidium guajava* (Family: Myrtaceae)
Local Name: Guava, Marood, Amrud
The phytocomponents of *Psidium guajava* strictinin, isostrictinin and pedunculagin improve insulin sensitivity, so are effective in diabetes management [75]. The ethanol extract of the stem bark of *Psidium guajava* has been reported as an anti diabetic in Indian System of Medicine. The anti-hyperglycemic activity of ethanol stem bark extract this plant showed statistically noteworthy hypoglycemic activity in alloxan-induced hyperglycemic rats but was devoid of significant hypoglycemic effect in normal and normal glucose loaded rats (OGTT) [88].

### 34. *Punica granatum* (Family: Punicaceae)
Local Name: Pomegranate, Anar
According to Unani medicine, flowers of *Punica granatum* called Gulnar farsi are anti-diabetic and Anti-oxidant in nature [89]. The hypoglycemic activity of methanol extract of the *Punica granatum* Linn seeds at doses of 300 and 600 mg/kg, and chlorpropamide 200 mg/kg was administered to streptozotocin (STZ) induced diabetic rats. The seed extract (150,300, and 600mg/kg, orally ) caused a significant reduction of blood glucose levels in STZ induced diabetic rats by 47% and52%, respectively, at the end of 12 h [90].

### 35. *Ricinus communis*
(Family: Euphorbiaceae)
Local Name: Castor Bean, Aeradi, Dadla
The ethanol extract of *Ricinus communis* at 500mg/kg when orally administered in diabetic rats for 20 days, elevate insulin levels and improve lipid profile and body weight [91].

36. *Salvia lavandulifolia*
(Family: Lamiaceae, Labiateae)
Local Name: Spanish Sage
The hypoglycemic activity of infusions and suspensions of *Salvia lavandulifolia* showed greatest decrease in glucose levels (17-18%) with doses of 0.250 mg/kg in normoglycemic rabbits. On administering *Salvia* infusion simultaneously with glucose, antidiabetic activity was seen in glucose induced hyperglycemia. The daily administration of 0.250 mg/kg of infusion resulted in a 33% decrease in blood glucose levels in alloxan-diabetic rabbits [92].

37. *Saussurea lappa*
(Family: Asteraceae)
Local Name: Costus root, Kuth, Kutha, Kut
The alcoholic extract of the root of *S. lappa* treatment for 7 days in albino rats, shows a significant hypoglycemic response without an increase in plasma insulin on liver glycogen, blood glucose and plasma insulin [93].

38. *Tinospora cordifolia*
(Family: Menispermaceae)
Local Name: Tonic Wine, Ghiloy
The aqueous root extract of *T. cordifolia* on oral administration to alloxan diabetic rats, leads to a considerable decline in blood glucose and brain lipids. The effect of a dose of 400 mg/kg aqueous extract which could educes major antihyperglycemic effect in different animal models is equal to only one unit/kg of insulin [94].

39. *Trigonella foenum graecum*
(Family: Papilionaceae, Fabaceae)
Local Name: Fenugreek, Methi
*Trigonella foenum graecum* has been reported to cause glucose induced insulin release [73]. The amino acid hydroxy isoleucine present in *T. foenum graecum* seeds possess insulin stimulating properties [72] while hydroxyleucine enhances glucose stimulated insulin release by isolated islet cells in rats, mice and humans [18], [95], [96], [97]. In insulin dependent diabetic patients, the fenugreek diet significantly reduced fasting blood glucose by 54% in the 24 hr urinary glucose excretion and improved the glucose tolerance test indicative of the use of fenugreek seeds in diabetes management. Oral administration of varied doses (2 and 8 g/kg) of *T. foenum graecum* on oral administration to alloxan diabetic rats produced a major reduction in their blood glucose levels. The aqueous extract of fenugreek leaf produced a significant reduction in BGL while, an ethanolic extract produced no reduction in BGL in healthy and an administration of 0.8 gm/kg of the ethanolic leaf extract to diabetic rats produced a major reduction of BGL. The steroid saponins of fenugreek seeds when mixed with food (12.5 mg/day per 300gms body weight) and administered to healthy and STZ induced diabetic rats decreased total plasma cholesterol without any change in triglycerides and blood glucose levels, food intake and motivation to eat enhanced in healthy rats and the food consumption in diabetic rats was also stabilized and the disrupted free radical metabolism in diabetic animals may be normalized [98], [99].

40. *Vitis vinifera*
(Family: Vitaceae)
Local Name: Common Grapevine, Kawdach
Dosage of 250mg/kg body weight/d grape seed proanthocyanidins extracts (GSPE) as phyotherapeutic agents against Diabetic peripheral neuropathy (DPN) which is one of the most common diabetic chronic complications, were administered to diabetic rats for 24weeks. GSPE enhanced the Motor nerve conductive velocity (MNCV), mechanical hyperalgesia and superoxide dismutase (SOD) of diabetic rats associated nerval damage. This study presented an innovative identification of natural medicine effective against DPN [100].

41. *Withania somnifera*
(Family: Solanaceae)
Local Name: Winter Cherry, Ashwagandh

Hypoglycemic and hypolipidaemic effects of root (WSREt) and leaf extracts (WSLEt) of *Withania somnifera* were investigated after daily oral administered for eight weeks in alloxan induced diabetic rats in comparison with the standard drug glibenclamide. The levels of urine sugar, blood glucose, glycosylated hemoglobin (HbA1C), liver Glucose-6-phosphatase (G6P), aspartate transaminase (AST), alanine transaminase (ALT), acid phosphatase (ACP) and alkaline phosphatase (ALP), serum lipids except high density lipoprotein bound Cholesterol (HDL-c) and tissues like liver, kidney and heart lipids were significantly increased, however Hb, total protein, albumin, albumin- globulin (A-G) ratio, tissues protein and glycogen were significantly decreased in alloxan induced diabetic rats. Treatment for eight weeks to the alloxan induced diabetic rats with WSREt, WSLEt and glibenclamide instated the alterations of the above parameters to normal levels, signifying that WSREt and WSLEt have hypoglycemic and hypolipidaemic actions in diabetic rats [101].

CONCLUSION

In the present review an attempt has been made to investigate the antidiabetic medicinal plants which may be helpful to health professionals, scientists and scholars working in the field of pharmacology and therapeutics to develop antidiabetic drugs. The need of the hour is the scientific validation of the ethno botanical knowledge involving medicinal plants for the alleviation of diabetes mellitus. The antidiabetic effect may be due to the antioxidant property of the plants or by the stimulation of the β cell resulting in elevated insulin secretion, yet the precise mechanism is very exigent to be identified and explained also in view of the varied phyto-constituent classes (phenolic compounds, flavonoids, terpenoids, and coumarins). The Streptozotocin and alloxan induced diabetic animal models for the screening of anti-diabetic drugs are not exactly equivalent to human diabetes and consequently clinical trial is fundamentally required to exploit the plant drug clinically.

Acknowledgements

Authors are thankful to their respective Heads of Departments for encouragement and to the people of various areas of Jammu and Kashmir for providing necessary information related to these antidiabetic plants.

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