Review Article

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A REVIEW ON ANTIDIABETIC ACTION OF ASANADI GANA

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ABSTRACT

Herbs and herbal drugs have created interest among the people due to their various clinically proven effects and lack of side effect. Moreover the overuse of synthetic drug which result in higher incidence of adverse drug reaction, has motivated the human to revert to nature for safer herbal medicines. The current review focuses on Asanadi gana (group of drugs) and its potential in the treatment of diabetes mellitus, a major crippling disease worldwide leading to huge economic loss. The review describes, various aspect of Asanadi gana like active phytoconstituents having hypoglycemic action, pharmacological properties and mechanism of action of its ingredients. This review also focuses on the traditional therapeutic action of the asanadi gana dravyas mentioned in ancient classics. In various pharmacological studies, done in last few decades on the drugs of asanadi gana dravyas, it has been proved that almost all the constituents of asanadi gana, posses anti hyperglycemic, hypolipidemic, antioxidant and other therapeutic properties.

Keywords: Asanadi gana, antidiabetic, hypolipidemic and antioxidant property.

INTRODUCTION

Diabetes mellitus is a metabolic disorder characterized by hyperglycemia caused due to relative or absolute deficiency of insulin or by a resistance to the action of insulin at the cellular level. Lack of insulin affects the metabolism of carbohydrates, protein and fat and causes significant disturbance of water and electrolyte homeostasis. Diabetes mellitus has been known since ages and in present era it becomes a serious global health problem. Currently available drugs for diabetes include insulin and various oral hypoglycemic agents such as sulfonylurease, biguanides, meglitinide, thiazolidinediones, α-glucosidase inhibitors etc. Many of them have a number of serious adverse effects; therefore, the search for more effective and safer hypoglycemic agents is the one of the important area of investigation. Many plants with hypoglycemic properties are known from across the world since time immemorial. Various researches conducted in the last few decades on plants, mentioned in ancient literature or used traditionally for diabetes, have shown antidiabetic property. *Trigonella foenumgraecum, Momordica charantia, Tinospora cordifolia, Ficus bengalensis, Pterocarpus marsupium, Enicostema littorae, Gymnema sylvestre, Azadirachta indica, Syzigium cumini* are some of the most effective and the most commonly studied Indian plants in relation to diabetes. In Ayurveda there is description of *Asanadi gana* in the management of Switra, Kustha, Kaphaja-vikara, Krimi, Pandu, Prameha and Medodosha. All the ingredients of *Asanadi gana* are thoroughly documented in Ayurvedic classics and are well researched anti-diabetic drugs.

Asanadi gana dravya

Asanadi gana is a group of 23 drugs, which has been mentioned in Ashtanga Samgraha and Ashtanga Hridya under Vividhaganasamgraha adhyaya[1] and Shodhanadiganasamgraha adhyaya[2] respectively. The botanical name, family and therapeutic uses of asanadi gana dravya as mentioned in Ayurvedic literature are described in Table.

Pharmacological studies done on the drugs of Asanadi gana

To establish the traditional therapeutic effects on modern scientific parameters, various pharmacological studies have been done in last few decades on the drugs of Asanadi gana. Among these scientific researches only antidiabetic studies conducted on individual drugs of asanadi gana are reviewed here. The total cholesterol, triglyceride levels, VLDL and LDL were observed to be elevated in diabetic patients. It is also observed that oxidative stress is one of the main contributory factors in the patho-physiology of many diseases, including type-2 diabetes mellitus. So hypolipidemic and antioxidant studies done on these drugs are also discussed here.

Sanskrita Name	Botanical Name	Family	Therapeutic uses[1,2] as described in Ayurveda
Asana	*Pterocarpus marsupium* Roxb.	Leguminosae	• Switrahara • Kustha nasaka, • Kaphaja-vikaraghna, • Krimiroga hara, • Panduroga nasaka • Pramehahara • Medo dosha hara
Tinisha	*Ougenia oojeinensis* Roxb.	Leguminosae	
Bhurja	*Betula utilis D.* Don.	Betulaceae	
Shwetavaha	*Terminalia arjuna* Roxb.	Combretaceae	
Prakirya	*Holoptelea integrifolia* Planch.	Ulmaceae	
Khadira	*Acacia catechu* Wild	Leguminosae	
Kadara	*Acacia suma Buch.* Ham.	Leguminosae	
Bhandi	*Albizzia lebbeck* Benth.	Leguminosae	
Shimshapa	*Dalbergia sissoo* Roxb.	Leguminosae	
Meshasringi	*Gymnema sylvestre* R.Br.	Asclepiadaceae	
Shwetachandan	*Santalum album* Linn.	Santalaceae	
Raktachandana	*Pterocarpus santalinus* Linn.	Leguminosae	
Daruharidra	*Barberis aristata* DC.	Berberidaceae	
Tala	*Borassus flabellifer* Linn.	Palmae	
Palasha	*Butea monosperma* Lam.	Leguminosae	
Aguru	*Aquillaria agallocha* Roxb.	Thymelaceae	
Shaka	*Tectona grandis* Linn. f.	Verbenaceae	
Shala	*Shorea robusta* Gaertn.	Dipterocarpaceae	
Kramuka	*Areca catechu* Linn.	Palmae	
Dhava	*Anogeissus latifolia* wall.	Combretaceae	
Kalinga	*Holorrhena antidysentrica* Linn.	Apocynaceae	
Chagakarna	*Vateria indica* Linn.	Dipterocarpaceae	
Ashwakarna	*Dipterocarpus turbinatus* Geartn. f.	Dipterocarpaceae	

***Pterocarpus marsupium* Roxb.**

Pterocarpus marsupium Roxb. (Asana) is large deciduous tree, commonly known as Indian kino tree or Malabar kino tree, belonging to the family fabaceae. Recent pharmacological studies have shown that aqueous and alcoholic extracts of bark and heartwood of *Pterocarpus marsupium have* glucose lowering properties in diabetic animal models. *Pterocarpus marsupium* shows unique features, which include beta-cell protective and regenerative properties, as well as blood glucose lowering activity. *Pterocarpus marsupium* is a rich source of polyphenolic compounds. The heartwood contains several terpenoids and flavonoids including marsupin, pterosupin, trans- pterostilbene, and liquiritigenin; and aurone glycosides. The water extract of bark contain (-) epi-catechin an active principle.[3] The insulin like effects are exhibited by (-) epicatechin (increases glycogen content of rat diaphragm in a dose-dependent manner).[4] Marsupsin and pterostilbene, the constituents of the heartwood of *Pterocarpus marsupium* significantly lowered the blood glucose level of hyperglycemic rats, and the effects was comparable to that of 1,1-dimethylbiguanides (metformin).[5] A flavonoid fraction extracted from the bark of *Pterocarpus marsupium* Roxb. effectively reverse the alloxan-induced changes in the blood sugar level and the beta-cell population in the pancreas.[6] Treatment of diabetic rats with the methanol extract of *Pterocarpus marsupium* Roxb. wood for longer duration shows a protective effect by correcting glycosylated hemoglobin, serum protein, insulin, alkaline and acid phosphatase and albumin levels.[7] An aqueous extract of *Pterocarpus marsupium* Roxb. showed statistically significant hypoglycemic activity[8] Figure 1 *Pterocarpus marsupium*[9].

***Ougenia oojeinensis* Roxb.**

Ougeinia oojeinensis Roxb. (Fabaceae) known in hindi as 'Tinisa' and in sanskrit as 'Rathadru' is a deciduous trees, found in the outer Himalayas and sub-Himalayan tracts from Jammu to Bhutan up to an altitude of 1500 m. Phytochemical investigation on *Ougeinia oojeinensis* have reported the presence of tannin and isoflavanones. The heartwood contain homoferreirin and ougenin.[10] Both extracts (methanol and aqueous extract) of *Ougenia oojeinensis Roxb.* has significant antihyperglycemic activity in Streptozotocin-induced rats and have tendency of a significant decrease in the total cholesterol levels and triglyceride levels. It also increases the HDL level and is successful in suppressing the VLDL and LDL levels.[11] The methanol and aqueous extracts induced a significant reduction on blood glucose level in STZ-induced-diabetic rats as compared to the diabetic control group but methanol extract showed more significant antidiabetic activity as compared to aqueous extract.[11] The possible mechanism by which *Ougeinia oojeinensis* brings about its hypoglycemic action in diabetic rat may be by potentiating the insulin effect of plasma by increasing either the pancreatic secretion of insulin from the existing beta cells or by its release from the bound form. The total cholesterol, triglyceride levels, VLDL and LDL were observed to be elevated in diabetics but reduced by both extracts showing their beneficial effects.

***Terminalia arjuna* Roxb.**

Various study suggests that *Terminalia arjuna* Roxb. is very effective in reducing hyperglycemia and hyperlipidemia in diabetics. It protects the beta cells of the pancreas from free radical damage, allowing them to regenerate and produce insulin more effectively. These activities of *Terminalia arjuna* bark extract is contributed due to rich concentration of its active constituents include tannins, triterpenoid, saponins (arjunic acid, arjunolic acid, arjungenin, arjunglycosides), flavonoids, gallic acid, ellagic acid, oligomeric proanthocyanidin, phytosterols, calcium, magnesium, zinc, and copper. *Terminalia arjuna* extract is a potent antidiabetic agent and beneficial in the control of diabetes related abnormalities in serum lipid profile, renal markers and oxidative damage in liver and pancreas of HFD/STZ-induced rat model of T2DM.[12] Treatment of animals with Arjunolic acid (at a dose of 20 mg/kg body weight, orally) both prior and post to the STZ administration effectively reduced the adverse

effects caused by STZ by inhibiting the excessive Reactive Oxygen Species' and Reactive Nitrogen Species' formation as well as by down-regulating the activation of phospho-ERK1/2, phospho-p38, NF-κB and mitochondrial dependent signal transduction pathways leading to apoptotic cell death. Combining all, these results suggest that Arjunolic acid plays very beneficial roles against STZ-induced diabetes.[13] Methanolic extract of *Terminalia arjuna* (META) at the dose of 100 and 200 mg/kg orally significantly ($P < 0.001$) and dose-dependently reduced and normalized blood glucose levels as compared with that of STZ control group. Serum biochemical parameters were significantly ($P < 0.001$) restored toward normal levels in Methanolic Extract TA-treated rats as compared with STZ control. META treatment also significantly ($P < 0.001$) decreased lipid peroxidation. This study infers that *Terminalia arjuna* leaf demonstrated remarkable anti hyperglycemic activity in STZ-induced diabetic rats. The potential anti hyperglycemic action is plausibly due to its underlying antioxidant role.[14] Figure 2 *Terminalia arjuna*[15].

***Betula utilis* D. Don**

Betula utilis D. Don commonly known as 'Bhojapatra' is a traditional medicine and is known for its beneficial and medicinal value since long. The active constituents of *Betula utilis* shows various pharmacological effects like anti-hyperglycemic, anti-inflammatory, antioxidant, antimicrobial and anticancer activities. Its bark contains betulin, lupeol, oleanolic acid, acetyloheanolic acid, betulic acid, sitosterol, methyl betulonate and methyl betulterpenoid.[16] The ethanolic extracts of stem wood of *Betula utilis* D. Don exhibited significant fall in blood glucose profile in a single dose experiment on Streptozotocin-induced diabetic rats.[17] Figure 3 *Betula utilis*[18].

***Holoptelia integrifolia* Roxb.**

According to Ayurvedic literature survey, the plant *Holoptelea integrifolia* Roxb. (Chirabilva), is a medicinal plant, exhibits a wide range of biological activities. Various parts of *Holoptelea integrifolia* therapeutically used in inflammation, Dyspepsia, Flatulence, Colic, Intestinal worms, Vomiting, Wounds, Vitiligo, Leprosy, Filariasis, Diabetes, Hemorrhoids, Dysmenorrhoea, rheumatism etc. It has been found in a study that Methanol, Petroleum ether extract of leaves of *Holoptelea integrifolia* Roxb. have anti-diabetic activity in Alloxan induced method.[19] Treatment with leaves of *Holoptelea integrifolia* ethanolic extract shown significant decrease in blood glucose level, LDL, TG, Total cholesterol and VLDL in streptozotocine induced rats.[20] Figure 4 *Holoptelea integrifolia*[21].

***Acacia catechu* Wild**

Acacia catechu Wild (Cutch tree) belonging to the family Leguminosae is commonly used by many traditional healers in most of the herbal preparations for diabetes. The constituents reported in this plant are acacatechin, quercitin, quercitrin, tannin, l-epicatechin, catechin, catechutannic acid, dicatechin, gallocatechin etc. Ethyl acetate extract of *Acacia catechu* produce significant reduction of blood glucose level in albino rats.[22] 70 % methanol extract of 'kattha' (Heartwood extract of *Acacia catechu*) acts as an antioxidant, iron chelator and DNA protector which is partly due to the phenolic and flavonoid compounds present in it.[23] The ethanolic as well as aqueous extracts of the hard wood of *Acacia catechu* showed improvement on oral glucose tolerance post-sucrose load in normal rats and streptozotocin (STZ)-induced diabetic rats. The ethanolic extract of *Acacia catechu* heart wood also showed marked anti-dyslipidemic activity on HFD fed Syrian golden hamster as evidenced by around 43 % and 26 % decline in serum triglycerides and total cholesterol.[24] The ethanolic extract of *Acacia catechu* and the water insoluble fraction of ethanolic extract exhibited significant anti-hyperglycaemic activity and produced dose- dependent hypoglycemia in fasted normal rats. Treatment of diabetic rats with ethanolic extract and water-insoluble fraction of this plant restored the elevated biochemical parameters significantly ($p < 0.05$) to the normal level.[25] The mechanism behind this anti hyperglycemic activity of plant extracts and fractions involves an insulin-like effect, probably, through peripheral glucose consumption or enhancing the sensitivity of beta cells to glucose, resulting in increased insulin release.[25] Figure 5 *Acacia catechu*[26].

***Acacia suma* Buch. Ham.**

Acacia suma Buch. benging to family Leguminoae, is known as 'kadar' in Sanskrita and 'Shweta khadira' in hindi. The methanolic bark extract of *Acacia suma* have significant anti hyperglycemic activity in dose dependent manner. The oral administered extract significantly reduced elevated lipids and glycosylated haemoglobin in diabetic rats. The extract significantly improved glucose tolerance, body weight and liver glycogen of diabetic rats. The methanolic bark extract of *Acacia suma* has also potential to prevent the secondary complications of diabetes mellitus like atherosclerosis.[27] Figure 6 *Acacia suma*[28].

***Albizzia lebback* Benth**

Albizia lebbeck Benth (Family: Mimosaceae) is deciduous, unarmed tree found throughout India, tropical and subtropical regions of Asia and Africa. The bark of *Albizzia lebbeck* has been used by the local tribes of Mayurbhanj district of Odisha, India for the treatment of diabetes mellitus since time immemorial and they claim for its promising activity. Three main saponins named albizia saponins A, B and C; triterpenoids, polyphenols including flavones, procyanidines B_2 , procyanidines C_1 , alkaloids, epicatechine, albizinine, anthraquinone glycoside, aromatic alcohol etc were reported from the barks.[29] The methanol and aqueous extracts of the barks of *Albizia lebbeck* Benth. showed significant reduction in blood glucose levels in normal, glucose loaded and streptozotocin induced diabetic rats. The possible mechanism of action of the extracts may be due to by promoting the insulin release from the undestroyed β-cells or its action may be insulin like[30]. *Albizia lebbeck* bark extract posses antioxidant potential also [31]. Figure 7 *Albizia lebbeck*[32].

***Dalbergia sissoo* Roxb.**

In Indian traditional system of medicine, *Dalbergia sissoo* Roxb. (Family Fabaceae) is used for the treatment of diabetes mellitus. The ethanolic extract of *Dalbergia sissoo* leaves on oral administration at different doses (250 and 500 mg kg-1) to normal rats and alloxanized diabetic rats causes decrease in blood glucose level significantly.[33] *Dalbergia sissoo* ethanolic extract produced anti hyperglycemic effects in experimental diabetes by providing a regenerative modification against damage caused by alloxan to endocrine cells of the pancreas. However, ethanolic extract of *Dalbergia sissoo* may exert its hypoglycemic action by mechanisms such as stimulation of glucose uptake by peripheral tissues, inhibition of insulinase activity in both liver and kidney, inhibition of endogenous glucose production or inhibition of renal glucose re absorption. In a study, it is found that the Oral administration of ethanolic extract of *Dalbergia Sissoo* in Alloxan induced diabetic rats at the doses of 250 and 500 mg/kg for 21 days showed significant decrease in glucose, cholesterol, triglyceride VLDL, LDL and increase in body weight and HDL level, thereby exhibited significant antidiabetic activity[34]. Figure 8 *Dalbergia Sisso*[35].

***Gymnema sylvestre* R. Br.**

Gymnema sylvestre (Gurmar) is vine-like plant and is prescribed as herbal remedy for hyperglycemia. The ethanolic and aqueous extract of *Gymnema sylvestre* contain triterpene, gymnemic acids, gymnema saponins, gymnemasides. Other plants constituents are flavones, anthraquinones, hentri-acontane, α and β chlorophylls, phytins, resins, D-quercitol, inositol, formic acid, butyric acid, lupeol, β-amyrin and stigmasterol.[36] Among these mainly gymnemic acid is having antidiabetic, anti-saccharine and anti-inflammatory properties. The extract of *Gymnema sylvestre*, is useful in controlling blood sugar to treat type-2 diabetes. It increases the insulin producing beta cells of pancreas and significantly reduces the metabolic effects of sugar by preventing the intestine from absorbing the sugar molecules during the process of digestion.[37] In a study, in 22 patients of Type 2 diabetes mellitus on conventional oral anti-hyperglycemic agents an extract from the leaves of *Gymnema sylvestre* (GS_4) was administered for 18–20 months as a supplement to the conventional oral drugs. During GS_4 supplementation, the patients showed a significant reduction in blood glucose, glycosylated haemoglobin and glycosylated plasma proteins, and conventional drug dosage could be decreased. Five of the 22 diabetic patients were able to discontinue their conventional drug and maintain their blood glucose homeostasis with GS_4 alone. These data suggest that the *beta* cells may be regenerated / repaired in Type 2 diabetic patients on GS_4 supplementation.[38] *Gymnema sylvestre* regulates the blood sugar levels by increasing the enzyme activities affording the utilization of glucose by insulin dependent pathways. Thus *Gymnema sylvestre* corrects the metabolic derangements in the liver, kidney and muscles.[39] Figure 9 *Gymnema sylvestre*[40].

***Santalum album* Linn**

Santalum album Linn (Santalaceae), commonly known as Sandalwood or Shwetachandana is used traditionally for its anti hyperlipidemic and diuretic activity. The volatile oil extracted from *Santalum album* Linn. derived from the roots and heartwood is colorless to yellowish, viscous liquid with peculiar heavy sweet odor, the chief constituents of the oil is santalol (90 % or more) a mixture of two primary sesquiterpene alcohols, viz, α-santalol and β-santalol. Various other constituents of sandalwood oil in categories of tannins, terpenes, resins and waxes have been reported. *Santalum album* petroleum ether fraction has potential anti hyperglycemic and anti hyperlipidemic activity that can help in overcome the insulin resistance.[41] Figure 10 *Santalum album*[42].

***Pterocarpus santalinus* Linn**

Pterocarpus santalinus Linn (Red sandalwood or Raktachandana), member of the fabaceae plant family, contains santalic acid and has thus been used as a traditional medicine. From the heartwood of *Pterocarpus santalinus* a group of six closely related sesquiterpenes has been isolated which includes three new sesquiterpenes – namely isopterocarpolone, pterocarptriol and pterocarpdiolone. These sesquiterpenes include the known β-eudesmol, pterocarpol and cryptomeridiol.[44] Phytochemical analysis of active fraction of *Pterocarpus santalinus* showed the presence of flavonoids, glycosides and phenols. Biological testing of the active fraction demonstrated a significant antidiabetic activity by reducing the elevated blood glucose levels and glycosylated hemoglobin, improving hyperlipidemia and restoring the insulin levels in treated experimental induced diabetic rats. Further elucidation of mechanism of action showed improvement in the hepatic carbohydrate metabolizing enzymes after the treatment. It suggests that active fraction of ethanolic extract of bark of *Pterocarpus santalinus* decreases streptozotocin induced hyperglycemia by increasing glycolysis and decreasing gluconeogenesis.[43] The use of the aqueous extract of *Pterocarpus santalinus* causes reduction in hyperglycemia, serum lipids, HbA_1C and improvement in lipid peroxidation and brain, liver and heart tissue masses.[44] The progression of Diabetes Mellitus in the subjects is largely attributed to free radical generation. The impacts of these free radicals are observed as lipid peroxidation and its resulting complications. In the diabetic subjects, the plasma and tissue lipid peroxidation products exhibited significantly higher concentrations than in the diabetic treated groups. The levels of MDA – the end products of lipid peroxidation – were lower in the subjects treated with *Pterocarpus santalinus* which can be attributed to an increase in superoxide dismutase activity, preventing free radical activity. Figure 11 *Pterocarpus santalinus*[45].

***Berberis aristata* DC**

Berberis aristata DC (Berberidaceae) commonly called as 'Daruharidra' or 'Daruhaldi' is an erect spinous shrub. It contains number of alkaloids among them the most important is berberine. Other alkaloids are berbamine, aromoline, karachine, palmitine, oxyacanthin and

oxyberberine.[46] The extract of *Berberis aristata* (root) besides being safe, lowered the blood glucose significantly without any hypoglycemic effect on their control counterparts. It increased CAT, SOD, GPx, GR activity significantly and reduced lipid peroxidation and protein carbonylation. It also increased the glucokinase and glucose-6-phosphate dehydrogenase activities and decreased glucose-6-phosphatase activity in diabetic rats which play a critical role in glucose homeostasis. So the extract of *Berberis aristata* (root) has strong potential to regulate glucose homeostasis through decreased gluconeogenesis and oxidative stress.[47] Administration of ethanol extract of *Berberis aristata* roots in diabetic rats showed dose dependent reduction in hyperglycemia. The levels of serum total cholesterol, triglyceride, aspartate aminotransferase, alanine aminotransferase, serum creatinine and blood urea were significantly decreased in diabetic rats when compared with diabetic control rats.[48] Significant hypoglycemic activity and hypolipidemic activity has been found in the methanolic extract of *Berberis aristata* DC.[49] Figure 12 *Berberis aristata*[50].

***Borassus flabellifer* Linn.**

Borassus flabellifer Linn of the Arecaceae family, locally called as Tal, and English Name is Palmyra palm, is a tall tree attaining a height of about 30 m. Studies on this plant have revealed the presence of several steroidal saponins, a polysaccharide, and a triterpenes. The fresh pulp is reportedly rich in vitamins A and C while the fresh sap is a good source of vitamin B-complex. Male inflorescence constitutes spirostane-type steroid saponins like borassosides and dioscin. It also contains 20 known steroidal glycosides and carbohydrates like sucrose. *Borassus flabellifer* Linn. has potent antidiabetic[51,52] and antioxidant[53] property. Figure 13 *Borassus flabellifer*[54].

***Butea monosperma* Lam**

Butea monosperma Lam belonging to the family Fabaceae, is a medium sized deciduous, erect tree. It is commonly called as Plasha and Dhaka. In English it is known as 'Flame of the Forest' because of its clusters of orange colored flowers. The flowers are good source of flavonoids. The contents of flowers are butein, butrin, isobutrin, plastron, coreipsin and isocoreipsin. The compound isolated from stem bark is stigmasterol, stigmasterol-βD-glucopyranoside, nonacosanoic acid, 3α-hydroxyeuph-25-ene etc. The gum is powerful astringent. Daily treatment of alloxan-induced diabetic animals with 50 % ethanolic extract of *Butea monosperma* flowers (BMEE) for 45 days significantly lowered blood glucose level. The level of serum total cholesterol, triglyceride, low-density lipoprotein and very low-density lipoprotein cholesterol were also lowered, whereas the level of high-density lipoprotein cholesterol was significantly elevated. Oxidative damage in the liver, pancreas and kidneys of diabetic mice was nullified by BMEE.[55] The anti hyperglycemic activity of the ethanolic extract of *Butea monosperma* (BMEE) was studied in glucose-loaded and alloxan-induced diabetic rats. In a study it has been seen that single dose treatment of ethanolic extract of *Butea monosperma* (BMEE) (200 mg/kg, p.o.) significantly improved glucose tolerance and caused reduction in blood glucose level in alloxan-induced diabetic rats.[56] Oral administration of the ethanolic extract of the *Butea monosperma* seeds (300 mg/kg b.w.) have antidiabetic, hypolipaemic and anti peroxidative effects in non-insulin dependent diabetes mellitus rats.[57] Figure 14 *Butea monosperma*[58].

***Aquilaria agalocha* Roxb.**

Aquilaria or agarwood (Thymelaeaceae) is now widely cultivated for its resin. Various parts of *Aquilaria agalocha* were reported to have several pharmacological activities. In a study, the effects of methanol, water and hexane crude extracts of agarwood leaf on hyperglycemia in streptozotocin-induced diabetic rats were investigated. Only methanol and water extracts at the dose of 1 g/kg body weight lowered the fasting blood glucose levels, 54 and 40 %, respectively. The results were comparable to 4 U/kg body weight of insulin (73 %). The methanolic and water extracts of agarwood leaves also exhibited antioxidant activities in the present study, but their contribution to anti-hyperglycemic and enhancement of glucose uptake activities are not known. The anti hyperglycemic and glucose uptake enhancement activities of agarwood methanol and water extracts are similar to those of insulin.[59] Figure 15 *Aquilaria agalocha*[60].

***Tectona grandis* Linn.**

Tectona Grandis Linn. (saak or teak wood), an indigenous medicinal plant, is traditionally used in the treatment of diabetes. *Tectona grandis* wood contains, in its cavities, white crystalline deposits of calcium phosphate, silica and ammonium and magnesium phosphates, which are also resins. Seed contains bland fatty oil. Lapachol is a naphthoquinone and lapachonone, found in *Tectona* wood and bark, has anti-hyperglycemic effect. *Tectona grandis* Linn. sawdust contains deoxylapachol and tectoquinnone as active components. Oral administration of *Tectona grandis* (2.5 and 5 g/kg body wt.) for 30 days shows a significant reduction in blood glucose in alloxan induced diabetic rats. The anti-hyperglycemic activity of *Tectona grandis* bark extract may be due to the regeneration of islets' β-cells following destruction by alloxan, as the extract shows significant reduction of blood glucose levels in 15 and 30 days, at a dosage of 2.5 and 5 g/kg body wt.[61] In a study, ethenolic extract of bark of *Tectona grandis* showed significant decrease in plasma glucose and serum triglyceride levels at the dose of 100 and 200 mg/kg, p.o. and also stimulated glucose uptake in skeletal muscles. The levels of antioxidant enzyme GSH, SOD and catalase were significantly increased and there was significant decrease in level of LPO.[62] Methanol extract of *Tectona grandis* flowers possesses anti diabetic, anti hyperglycemic and antioxidant activity.[63] Figure 16 *Tectona grandis*[64].

***Shorea robusta* Gaertn.**

Shorea robusta Gaertn. Of family Dipterocarpaceae is commonly known as 'Sal'. The oleoresin of *Shorea robusta* Gaertn is called as shala niryasa, rala, sarja rasa etc. which is known for the therapeutic properties such as wound healing[65], anti-inflammatory[66], antipyretic[66], analgesic[67] and antibacterial effect. Phytochemical

screening of the different extracts of *Shorea robusta* showed the presence of alkaloids, carboxylic acids, fatty acids, phenols, saponins Triterpenoids, Flavonoids, Glycosides, Resins and steroids. Catechols, coumarins, proteins, tannins, volatile oils, Fixed oils were observed in low concentrations. Figure 17 *Shorea robusta*[68].

***Areca catechu* Linn.**

Areca catechu Linn. (Palmaceae), commonly known as Areca nut in English, is a perennial tree occurring throughout the Indian subcontinent and used traditionally for several medicinal purposes. Preliminary phytochemical analysis revealed the presence of triterpenoids and steroids in petroleum ether extract; chloroform extract revealed the presence of alkaloids and triterpenoids; metahnol extract revealed the presence of alkaloids, steroids, saponins, tannins, glycosides and carbohydrates. The pet ether, chloroform and methanol extracts of *Areca catechu* leaf possessed remarkably effective antidiabetic potential against streptozotocin induced diabetes in Wistar rats.[69] The observed antidiabetic activity of all the extracts may be due to mainly the presence of triterpenoid compounds. Figure 18 *Areca catechu*[70].

***Anogeissus latifolia* Wall.**

Anogeissus latifolia, (Combretaceae), locally known as Dhava, is a moderate sized tree characteristic of dry deciduous forests and available throughout India. The bark contains 12-18 percent tannin. The acetone extract of the leaves gives a gallotannin, gallic acid, chebulic acid and small amount of ellagic acid. The sapwood contains ellagic acid and the heartwood contains quercetin, myricetin and trimethylellagic acid.[71] *Anogeissus latifolia* have potential to attenuate insulin resistance and reverse the metabolic dyslipidemia caused by metabolic changes induced by high fructose diet in rats.[72] *Anogeissus latifolia* extract has potent antioxidant activity, achieved by scavenging abilities observed against DPPH, and lipid peroxidation. The percentage of gallic acid in the bark ascertains that the antioxidant activity may be due to the same.[73] Figure 19 *Anogeissus latifolia*[74].

***Holorrhena antidysentrica* Wall.**

Holorrhena antidysenterica belonging to the family of Apocynaceae is known as "Indrajav," and "Vatsaka" in Sanskrit is a shrub, distributed throughout India up to an altitude of 4,000 ft. In Indian traditional medicine, this plant has been considered as a popular remedy for the treatment of dysentery, diarrhea and intestinal worms. The preliminary phytochemical evaluation revealed the presence of alkaloids, flavonoids, triterpenoids, sterol, quinine, saponin, glycosides etc. which are known to posses various pharmacological effects.[75] The aqueous extract of seed of *Holorrhena antidysenterica* has a promising antidiabetic effect in correlation with anti hyperlipidemic activity without any toxicity induction.[76] Figure 20 *Holorrhena antidysenterica*[77].

***Vateria indica* Linn.**

Vateria indica Linn. of Dipterocarpaceae, commonly known as 'White Dammar' is a large elegant evergreen tree, up to 30 m. high. The resin exuded by tree is known as Piney resin, White Dammar or Dhupa and is commercially very important. The resin is complex mixture of several triterpine hydrocarbons, ketones, alcohol, acids along with small quantity of sesquiterpenes. On distillation oleoresin gave an essential oil which consists of phenolic constituents and azulenes. The fruit shell contains 25 % tannins. A glucoside, bergenin has been isolated from the seeds and the bark. The phenolic constituents separated from the bark are dl-epicatechin, (-) fisetinidol, (-) epiafzelechin, 2', 6', 4-trihydroxychalcon and 2, 3, 4, 4'-tetrahydroxystilbene.[78] The essential oil shows marked antibacterial activity against gram-negative and gram-positive bacteria. The resin finds extensive use in Indian medicines. Figure 21 *Vateria indica*[79].

***Dipterocarpus turbinatus* Geartn.**

Dipterocarpus turbinatus Geartn. is commonly is known as 'Telia gurjan' in Hindi and 'Common gurjan tree' in English. It is the principle source of kanyin oil of Burma and the gurjan oil of Bengal. Pale yellow oil with a Balsamic odour is obtained through steam distillation of the Oleo-resin which is principle constituents of the trunk. The essential oil consists of two distinct sesquiterpenes, α and β gurjunene and gurjunic acid.[80] Figure 22 *Dipterocarpus turbinatus*[81].

CONCLUSION

Diabetes mellitus is a metabolic disorder caused due to relative or absolute deficiency of insulin or insulin resistance at the cellular level. This review article has presented the antidiabetic action of Asanadi gana, a group of 23 plants which has been mentioned in Ashtang Samgraha and Ashtanga Hridaya. It showed that these plants have varying degree of hypoglycemic activity along with hypolipidemic and antioxidant property. The potency of these drugs is significant and they have negligible side effects than the oral hypoglycemic drugs (OHA). The antidiabetic activity of these plants are attributed to the presence of polyphenols, terpenoids, alkaloids, flavonoids, glycosides and other active constituents, which shows reduction in blood glucose level. Numerous mechanisms of actions have been predicted for these plant extracts. Some herbal drugs have effects on the activity of pancreatic β-cells (insulin release, β-cell regeneration) or some drugs enhance the insulin sensitivity and some of the plant extracts exhibit insulin-like activity. Other mechanisms may involve improved glucose homeostasis (increase of peripheral utilization of glucose, increase of synthesis of hepatic glycogen or decrease of glycogenolysis), inhibition of intestinal glucose absorption, reduction of glycaemic index of carbohydrates, reduction of the effect of glutathione. All these actions may be responsible for the reduction and abolition of diabetic complications. Thus there is need for more investigations to evaluate the clear mechanism of action of these medicinal plants with anti-diabetic effect. Further it is required to evaluate the anti-diabetic effect of these drugs in clinical setting with appropriate parameters.

Figure 1: ***Pterocarpus marsupium***

Figure 2: ***Terminalia arjuna***

Figure 3: ***Betula utilis***

Figure 4: ***Holoptelia integrifolia***

Figure 5: ***Acacia catechu***

Figure 6: ***Acacia suma***

Figure 7: ***Albizia lebback*** **benth**

Figure 8: ***Dalbergia sissoo***

Figure 9: ***Gymnema sylvestre***

Figure 10: ***Santalum album***

Figure 11: ***Pterocarpus santalinus***

Figure 12: ***Berberis aristata***

Figure 13: ***Borassus flabellifer***

Figure 14: ***Butea monosperma***

Figure 15: ***Aquilaria agallocha***

Figure 16: ***Tectona grandis***

Figure 17: ***Shorea robusta***

Figure 18: ***Areca catechu***

Figure 19: ***Anogeissus latifolia***

Figure 20: ***Holorrhena antidysentrica***

Figure 21: ***Vateria indica***

Figure 22: ***Dipterocarpus turbinatus***

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