Review Article

Available online through
www.ijrap.net

IJRAP

HYPOGLYCAEMIC ACTIVITY OF DIFFERENT EXTRACTS OF VARIOUS HERBAL PLANTS

Singh Ayodhya[1], Singh Kusum[1], Saxena Anjali[2*]

[1]M.M.H. college, Ghaziabad, Uttar Pradesh, India
[2]S.I.E.T, Gr.Noida, Uttar Pradesh, India

Received: 19-07-2010; Revised: 16-08-2010; Accepted: 14-09-2010

ABSTRACT

The hypoglycaemic or anti-diabetic activity of various extracts of various plants have been evaluated in Alloxan induced diabetic rats. In our experiments 30 medicinal plants have been selected for thorough studies from various plants like- **Pterocarpus marsupium, Azadirachta indica, Allium sativum, Brassica juncea etc** many of them seem to act directly on pancreas and stimulate insulin level in blood. This paper aims to provide a comprehensive review on various plant species from Indian biosphere, which have been shown to display potent hypoglycaemic activity.

KEYWORDS: Hypoglycaemic activity, Alloxan induced diabetic rat, Medicinal plants

***Address for correspondence**
ANJALI SAXENA
Sr. lecturer
Department of Chemistry
S.I.E.T, Gr.Noida
Uttar Pradesh, India
Tel No: +919212362423
E mail - anjalisaxena84@gmail.com

INTRODUCTION

Hyperglycaemia or diabetes mellitus is caused by inherited or acquired deficiency in production of insulin by the pancreas or by the ineffectiveness of the insulin produced. Such a deficiency results in increased concentration of glucose in the blood, which in turn damage many of the body systems in particular the blood vessels and nerves. Chronic hyperglycaemia during diabetes causes glycation of body proteins that in turn lead to secondary complications effecting eyes , kidneys, nerves and arteries. A part from currently available therapeutic options many herbal medicines have been recommended for the treatment of diabetes medicinal plants have the advantage of having no side-effects. Some of them are be used in traditional systems of medicines from hundreds of the years in many countries of the world. Till today met forming is the only ethical drug approved for the treatment of NIDDM patient which is derived from a medicinal plants Galega officinalis historically used for treatment of Diabetes in medieval Europe.

According to WHO more than one million people rely on herbal medicines to some extants. The WHO has listed 21,000 plants have reported medicinal uses around the world. India has rich medicinal plant flora of some 25,000 species of these 150 species is commercially used for extracting medicines or drug formulation.

In India the medicines the use of medicinal herbs is as old as 1500 BC, underline the medical culture of India both folk traditions as well as codified knowledge system is a deep understandings of the medicinal value of the plants starting with the references in the Atharveda. We have textual evidence of a tradition of use of medicinal plants that is more than 3000 years old.

Over the last few years, researchers have aimed at identifying and validating plants derived substances for the treatment of various diseases. Interestingly, it is estimated that more than 25% of modern medicines are directly or indirectly derived from plants.

In this context, it worth mentioning that Indian plants are considered a vast source of several pharmacologically active principles and compounds that are commonly used in home remedies against multiple ailments .Neem and turmeric are quite popular among these important medicinal plants and several pharmacologically active compounds have been isolated and extracted from these plants[.1-10]

Pterocarpus marsupium(commonly known as vijaysar) is another Indian plant, which has enormous traditional uses against various diseases and bioactive compounds have been isolated from this plant also. In hilly regions throughout the Deccan Peninsula, and extending to Gujarat, Madhya Pradesh, Uttar Pradesh, Bihar and Orissa .In India, it grows wild especially in dry forest,outer Himalayas Shivaliks, South Indian plateau with altitudes ranging from 250-1200m and also cultivated throughout Indian subcontinent. . In a clinical study, oral administration of 2,3 and 4gm of aqueous study of Vijaysar has been given per day to control fasting and post-prandial glucose levels by 12 weeks in 73, 16 and 10 % respectively of the 67 out of 97 patients who responded to therapy.[(11)] leaves, stem and roots of this plant are used as ethno-medicines against various human ailments. Extensive chemical investigations on various part of the tree have been carried out and more than 50 compounds have been isolated. which are biologically active against various major and minor diseases including Diarrhea, dysentery, leucoderma, elephantiasis etc.

Therefore in this article comparison between different medicinal plants having hypoglycaemic and anticatract activities are illustrated. This article will enhance the existing knowledge of medicinal plants, and also create the awareness of possible new therapeutic uses for t he development of pharmaceutical entities or dietary adjuncts for better health care in the near future.

LIST OF COMPARATIVE STUDY OF THE VARIOUS MEDICINAL/ HERBAL PLANTS FOR HYPOGLYCAEMIC AND ANTICATARACT AILMENT

PLANT NAME/ FAMILY	COMMON NAME	PART OF PLANT USED	TYPE OF EXTRACT	DOSE PARAMETER	OBSERVED RESULTS
Aegle marmelos (L.) Correa ex Roxb. (Family: Rutaceae)	Holy Fruit Tree	Leaf	Aqueous leaf extract [12]	Antihyperglycemic activity of aqueous leaf extract in streptozotocin induced diabetic rats.[12] Each group of animals was treated daily over 14 days orally by different doses by means of a catheter under mild ether anaesthesia	Increases utilization of glucose; either by direct stimulation of glucose uptake or via the mediation of enhanced insulin secretion [13]
Allium cepa L. [Family: Liliaceae]	Onion	Bulb [14]	Ether soluble fraction of onion[14]	Hypoglycemic activity of ether soluble fraction of onion (0.25 mg/kg p.o.) in normal rabbits [14]	Lowers blood glucose level and has potent antioxidant activity, which may account for the hypoglycemic potential
.*Allium sativum* L. [Family: Alliaceae]	Garlic	Whole Plant	ethanol, petroleum ether and ethyl acetate extract in alloxanized rabbits [15]	Antihyperglycemic activity of ethanol, petroleum ether and ethyl acetate extract in alloxanized rabbits at a dose of 0.25 mg/kg, orally [15]	It has been found that the ethyl ether extract from garlic is the most potent and active principle producing maximum hpoglcaemic activity due to increased insulin like activity of plasma.
Aloe vera (L.) Burm.f. [Family: Aloaceae]	Aloe	Whole Plant [16]	leaf pulp extracts[17]	Hypoglycemic activity of the plant (200 and 300 mg/kg p.o.) on normal fasted rats, oral glucose-loaded rats and streptozotocin-induced diabetic rats [16] Hypoglycaemic activity of leaf pulp extracts in type I and type II diabetic rats [17]	Maintains glucose homeostasis by controlling the carbohydrate metabolizing enzymes [16]
Artemisia pallens Wall. ex DC. (Family: Compositae)	Davana	Aerial parts	Methanol extract of the aerial parts [18]	Antihyperglycemic activity of aerial parts (100 mg/kg, orally) in glucose-fed hyperglycaemic and alloxan-induced diabetic rats. Moderate hypoglycaemic effect (1000 mg/kg) in fasted normal rats [18]	Inhibits glucose re-absorption or increase in peripheral glucose utilization [18]

Annona squamosa L. [Family: Annonaceae]	Sugar apple	Leaf	Ethanolic leaf-extract [19]	Hypoglycemic and antihyperglycemic activities of ethanolic leaf-extract (350 mg/kg, orally) in normal, streptozotocin (STZ)-diabetic rats and alloxanized rabbits [19]	Lowers blood glucose level
Andrographis paniculata Nees (Family: Acanthaceae)	King of Bitter.	Whole Plant	Aquous extract	Hypoglycemic and antihyperglycemic activity in normal and streptozotocin induced diabetic rats, orally. Its hypoglycaemic effect has been tried in various way. scan prevent induction of hyperglycaemia significantly (P <0.001) induced by oral administration of glucose 2 mg/kg body weight.[20]	Prevents glucose absorption from gut [20].
Azadirachta indica A. Juss. (Family: Meliaceae)	Neem	Leaf [21]	Leaf extract [21]	Hypoglycemic and antihyperglycemic activities of leaf extract in normal and streptozotocin-induced diabetic rat . Blood sugar lowering unit (BLU) of activity of each leaf extract and tolbutamide was calculated by ED50 values. Statistical analysis revealed significant (P<0.05) variation among the treatments as well as doses with regard to their blood sugar lowering capacity.[21]	Exhibits hypoglycaemic activity without altering the serum cortisol concentration [21]
Biophytum sensitivum (L.) DC	Life Plant	Whole plant [22] leaf [23]	leaf extract	Hypoglycemic activity of the plant on glucose homeostasis in rabbits [22] Hypoglycemic activity of the plant leaf extract in alloxan diabetic male rabbits [23]	Stimulates pancreatic beta cells to release insulin [23]
Beta vulgaris L. [Family: Chenopodiaceae]	Garden beet	Root	Root extract	Hypoglycemic activity of Betavulgarosides II–IV, isolated from the root of *Beta vulgaris* L. in an oral glucose tolerance test in rats [24]	Lowers blood glucose level [24]
Brassica juncea (L.) Czern. (Family: Brassicaceae)	Brown mustard	Whole plant		Hypoglycemic activity of *Brassica juncea* diet (10%, w/w) in normal rats upon oral administration for 60 days [25]	Increases the concentration of hepatic glycogen and glycogenesis and suppressed the activity of glycogen phosphorylase and gluconeogenic enzymes, lead to reduction in glycogenolysis and gluconeogenesis [25]
Boerhavia diffusa L. (Family: Nyctagina	Tar vine	Leaf	Aquous leaf extract [26-28]	Hypoglycemic and antihyperglycemic activity of aqueous leaf extract (200 mg/kg p.o., daily for 4 weeks) in normal and alloxan induced diabetic rats [26,27]	Increases plasma insulin levels and improves glucose tolerance, produced significant antioxidant activity [26,27]

ceae)				Hypoglycemic activity of aqueous leaf extract at a dose of 100, 200 and 400 mg/kg in alloxan induced diabetic rats [28]	
Cassia auriculata L. (Family: Legumino sae)	Tanner's Cassia	Flower [30]	Aqueous flower Extract [29,30]	Antihyperglycemic and antihyperlipidemic activity of aqueous flower extract in streptozotocin-induced diabetic rats upon oral administration at different doses for 30 days [30] .	Suppresses enhanced gluconeogenesis during diabetes and enhance utilization of glucose through increased glycolysis [30] in addition to pronounced alpha-glucosidase inhibitory actions resulting in a significant and potent lowering of blood glycemic response [29]
Caesalpin ia bonducell a (L.) Roxb. (Family: Cesalpina ceae)	Chinese Cinnam on	Seed[31-33]	The aqueous and 50% ethanolic seed extracts [31,32]	Hypoglycemic and antihyperglycemic activities of the aqueous and 50% ethanolic seed extracts in normal and streptozotocin-diabetic rats [31] Hypoglycemic activity of aqueous and ethanolic extracts in chronic type II diabetic model with an increase in secretion of insulin from isolated islets [32] Antihyperglycemic activity of the seed extracts in type II diabetic Long Evans rat [33]	Increases the release of insulin from pancreatic cells[31]
Cajanus cajan (L.) Millsp. (Family: Fabaceae)	Pigeon pea	Leaves and stem, twings	Aqueous leaf and stem extract [34]	Glucose tolerance enhancing activity of aqueous leaf and stem extract in oral glucose tolerance test [34] Hypoglycemic activity of cooked diet in healthy human volunteers [35]	Leaf juice is used against diabetes. Seed paste is used as energy stimulant. It Lowers plasma glucose lavel.
Citrullus colocynthi s (L.) Schrad. (Family: Cucurbita ceae)	Bitter apple	Seed [36]	Aqueous extract , glycosidi c and saponin extract (50 mg/kg) [36]	Blood glucose lowering activity of aqueous seed extract(300 mg/kg) in normal and streptozotocin (STZ)-induced diabetic rats upon daily oral dministration for 2 weeks [36]	The oral administration of plant extract reduced the plasma lavel of AST and LDH significantly. The oral administration of aqueous extract of the plant can ameliorate some of the toxic effect of sterptozotocin [36].
Coccinia indica Wight & Arn. (Family: Cucurbita ceae)	Ivy gourd	Leaves [37-40]	Alcoholi c leaf extract [37-40]	Antihyperglycemic activity of dried extract (500 mg/kg p.o., for 6 weeks) in 30 diabetic patients [37] Hypoglycemic activity of the leaf extract in a double blind control trial in human subjects (39,40) Blood glucose lowering activity of 60% ethanol leaf extract (200 mg/kg, orally) [38]	Suppresses glucose synthesis, through depression of the key gluconeogenic enzymes glucose-6-phosphatase and fructose-1,6-bisphosphatase and enhances glucose oxidation by shunt pathway through activation of its principal enzyme glucose-6-phosphate dehydrogenase [38]. Also has an insulin secretagogue effect (39,40) and acts like insulin by correcting elevated enzymes in glycolytic pathway and

					restoring LPL activity in lypolytic pathway with control of hyperglycemia in diabetes [37]
Casearia esculenta Roxb. (Family: Flacourtiaceae)	Carilla	Root	Root aquous extract	Root extract (300 mg/kg p.o. for 45 days) in normal and streptozotocin-induced diabetic rats [41]	Exhibits significant reduction in blood glucose level, a decrease in the activities of glucose-6-phosphatase and fructose-1,6-bishosphatase and an increase in the activity of liver hexokinase, resulting in potent hypoglycemic activity[41]
Catharanthus roseus (L.) G. Don. (Family: Apocynaceae)	Madagascar periwinkle	Leaf & twigs	Ethanolic leaf extract, dichloromethane: methanol extract of leaves and twigs	Dichloromethane: methanol extract of leaves and twigs in streptozotocin (STZ) induced diabetic rat (500 mg/kg p.o., for 7 and 15 days) [42] The extract (500 mg/kg) in streptozotocin rats and in oral glucose tolerance test [43]	Increases metabolization of glucose [42]
Camellia sinensis Kuntze (Family: Theaceae)	Green tea	Leaves	Hot water extract of green tea	In streptozotocin (STZ)-diabetic rats [44,45]	Epigallocatechin gallate, present in tea increases insulin activity and prevent oxidative damages, responsible for the hypoglycemic activity [44,45]
Enicostemma littorale Blume (Family: Gentiaceae)	Blume	Whole plant	whole plant aqueous extract	Whole plant aqueous extract (1 and 2 g/kg) in alloxanized rats upon oral administration for 45 days [46] Insulin enhancing activity of a single dose of aqueous extract of plant (15 g dry plant equivalent extract per kg) in alloxan-induced diabetic rats [47] Glucose lowering activity of aqueous extract (2 g/kg p.o.) daily for 6 weeks in neonatal non-insulin-dependent diabetes mellitus (NIDDM) rats along with a decrease in the elevated cholesterol, triglyceride and creatinine levels [48]	Enhances glucose-induced insulin release from isolated rat pancreatic islets, mediated through K (+)-ATP channel-dependent pathway [47]
Eugenia jambolana Lam. (Family: Myrtaceae)	Indian black berry	Seed powder,	Ethanolic whole seeds & seed coat extracts [49]	Hypoglycemic activity of ethanolic whole seeds, kernel (100 mg/kg of body weight) and seed coat extracts in streptozotocin-induced diabetic rats [49]	It exhibits normoglycemia and better glucose tolerance [49]
Ficus bengalensis L. (Family: Moraceae)	Banyan	Bark	3-*O*-beta-d-galactosyl cellobioside isolated from the bark [50]	Blood sugar lowering activity of a dimethoxy derivative of leucocyandin 3-*O*-beta-d-galactosyl cellobioside isolated from the bark in normal and moderately diabetic rats along with an increase in serum insulin in the diabetic rats at a dosage of 250 mg/kg for a 2 h period upon oral administration [50] Blood glucose lowering activity of bark extract in processes [50]	Inhibits insulin degradative processes [50]

Hibiscus rosa sinensis L. (Family: Malvaceae)	China Rose	Whole plant, leaf & flower	Alcoholic leaf extract [51] ethanol extract of the plant [52]	Hypoglycemic activity of alcoholic leaf extract (250 mg/kg p.o. for seven consecutive days) in glucose induced hyperglycemia model in rats [51] Hypoglycemic activity of single dose of ethanol extract of the plant in glucose-loaded rats at 120 min and blood glucose lowering effect after repeated administration for seven consecutive days at 30, 90 and 120 min after glucose loading [52]	Stimulates insulin secretion from pancreatic beta cells [52] and increases utilization of glucose, either by direct stimulation of glucose uptake or via the mediation of enhanced insulin secretion [51]
Helicteres isora L. (Family: Sterculiaceae)	Screw tree	Root	Ethanolic root extract [53] butanol root extracts [54]	Plasma glucose lowering activity of ethanolic root extract (300 mg/kg, after 9 days of administration) in insulin resistant and diabetic C57BL/KsJdb/db mice associated with a reduction in plasma triglyceride level [53] Antihyperglycemic activity of butanol root extracts (250 mg/kg) in glucose loaded rats [54]	Acts through insulin-sensitizing activity [54]
Mangifera indica L. (Family: Anacardiaceae)	Mango	Leaf	Aqueous leaf extract [55]	Hypoglycemic activity of aqueous leaf extract (1 g/kg p.o.), given along with as well as 60 min before glucose administration in streptozotocin-induced diabetic rats [55] Hypoglycemic activity of Mangiferin (10 and 20 mg/kg, i.p. once daily for 28 days) in STZ induced diabetic rats and improvement in oral glucose tolerance in glucose-loaded normal rats upon chronic administration (10 and 20 mg/kg, i.p.) for 14 days [56]	Possibly acts through intestinal reduction of the absorption of glucose [55] as well as pancreatic and extrapancreatic mechanisms [56]
Mucuna pruriens (L.) DC. (Family: Leguminosae)	Velvet bean	Whole plant [57,58] powdered seeds [94]	Alcohol extract of the plant [57]	Antihyperglycaemic effect of alcohol extract of the plant (100, 200 and 400 mg/kg/day) in alloxanized rats and insignificant glucose lowering effect in streptozotocin (STZ) diabetic mice [57] Blood glucose lowering activity of plant extract (200 mg/kg) upon daily oral feeding for 40 days in STZ-diabetic mice [58] Blood glucose lowering activity of powdered seeds (0.5, 1 and2 g/kg) in normal rabbits and hypoglycemic activity of the seed (1 and 2 g/kg body weight) in alloxan-diabetic rabbits [59]	Possibly acts through stimulation of the release of insulin and/or by a direct insulin-like action due to the presence of trace elements like manganese, zinc, etc. [59]
Morus alba L. (Family: Moraceae)	White mulberry	Leaf [60]	Hot water extract of leaves [60]	Hypoglycemic activity of hot water extract of leaves in fasted and non-fasted streptozotocin induced diabetic mice at a dose of 200 mg/kg, i.p. (60)	Acts by increasing glucose uptake [60]
Murraya koeingii (L.) Spreng. (Family: Rutaceae)	curry-leaf tree	Leaf [61,62]	leaf-powder [61,62]	Fasting as well as post-prandial blood sugar lowering effect of leaf-powder in Type II diabetic patients upon administration for a period of 1 month [61] Blood sugar lowering effect of the leaves in normal rats when administered as a diet (10%, v/v) for 60 days [62]	Increases glycogenesis and decreases glycogenolysis and gluconeogenesis [62]
Ocimum sanctum L.	Holy Basil	Whole plant, leaf	Leaf powder [64]	Plasma glucose lowering activity of plant extract (200 mg/kg for 30 days) in STZ induced diabetic animals revealing the effect of the extract on three	Its powdered leaf has produced potent hypoglyycaemic and

(Family: Lamiaceae)		[63,64]		important enzymes of carbohydrate metabolism, namely glucokinase, hexokinase and phosphofructokinase [63] Fasting blood glucose level reducing activity of the leaf powder, given along with food for 1 month, in normal and diabetic rats [64]	hypolipidmic effect in normal and diabetic rats[64]. Administration of mention dose led to decrease in plasma glucose lavel by 24.6%[63]
Punica granatum L. (Family: Punicaceae)	Pomegranate	Flower [65] seed [66]	Methanolic seed extract [65] ethanolic flower extract [66]	Hypoglycemic activities of methanolic seed extract (150, 300 and 600 mg/kg p.o.) in strepotozotocin diabetic rats at the end of 12 h [65] Blood glucose lowering activity of a 50% (v/v) ethanolic flower extract in glucose fed and alloxanized hyperglycemic rats [66]	Led to significant blood glucose lowering effect in normal, glucose-fed hypoglycaemic and alloxan-induced diabetic rats.[66]
Salacia reticulata Wight. (Family: Celastaceae)	Salacia	Whole Plant [67]	Plant tea [67] aqueous decoction [68,69]	Hypoglycemic activity of plant tea in type II diabetic patients in a randomised single centre double blind cross over clinical trial [67] Blood glucose lowering effect of aqueous decoction in fasted animals with improved glucose tolerance in laboratory animals [68,69]	Inhibits alpha-glucosidase activity [68,69]
Salacia oblonga Wall. (Family: Celastaceae)		Whole Plant [70]	Extract along with an alpha glucosidage [70]	Plasma glucose and serum insulin reducing activity of the extract (1000 mg/kg) along with an alpha glucosidage inhibitory activity in a double-masked randomized cross over clinical study in healthy adults [70]	The given dose reduced the plasma glucose and serum insulin incremental area under the curve by 23 & 29% respectively[70]
Swertia chirayita (Roxb. ex Fleming) H. Karst. (Family: Gentianaceae)	Indian Gentian	Whole Plant [71,72]	Hexane fraction of the plant [73] Hexane fraction of 95% ethanol extract [74]	Blood sugar lowering effect of Swerchirin (50 mg/kg p.o.) in healthy and streptozotocin treated (35 mg/kg i.v.) Charles Foster strain albino rats [71,72] Insulin releasing effect of the hexane fraction of the plant (250 mg/kgbody weight p.o. per day for 28 days) in albino rats along with a significant rise in liver glycogen [73] Blood glucose lowering activity of hexane fraction of 95% ethanol extract (250 mg/kg) in fed, glucose loaded and tolbutamide pretreated animals [74]	Stimulates insulin release from islets of Langerhans by depleting aldehyde-fuchsin stained beta-granules and immunostained insulin [71]
Scoparia dulcis L. (Family: Scrophulariaceae)	Sweet Broom weed	Whole Plant [75] Leaf [76]	Plant extracts [75] aqueous leaf extract [76]	The insulin secretagogue activity of the plant extracts in isolated mice pancreatic islets at a dose of 10 mg/ml [75] Hypoglycemic activity of aqueous leaf extract (0.15, 0.30 and 0.45 g/kg body weight for 45 days p.o.) in experimental diabetic rats along with a reduction in glycosylated haemoglobin and an increase in total haemoglobin [76]	It potentiates insulin pancreatic islets [75] release from pancreatic islets

CONCLUSION

Diabetes is a disorder of carbohyderate, fat and protrin metabolism caused due to attenuate production of insulin or due to its inhibitory action. Herbal treatments for diabetes have been used in patients with insulin dependent and non-insulin dependent diabetes, diabetic retinopathy, diabetic neuropathy etc. scientific validation of several Indian plants species have proved the efficacy of the herbs in reducing the blood sugar level. Hence extensive research is required to find out the mechanism of the action as well as the bioactivity of other compounds in crude extracts and to exploit their therapeutic potential to combat various disease. A discovery of novel efficacious drug can be developed through the extensive investigation of bioactivity of various compounds their mechanism of action pharmacotheraputic, toxicity, standardization and clinical trails. Thus in near future the herbal plants may play very important role in modern system of medicine.

ACKNOWLEDGEMENT

The authors are grateful to Dr. Ayodhyya singh Reader in M.M.H. college Ghaziabad for his continuous support and inspiration.

REFERENCE

1. Biswas K, chattopadhyay I, Banerjee RK & Bandyopadhyay U. Biological activities and medicinal properties of neem (Azadirachta indica) curr sci, 2002; 82:1336.
2. Bandopadhyay U, Biswas K, Chatterjee R, Bandopadyay D, chattopadhyay I, Ganguly C K, Chakraborty T, Bhattacharya K, & Banerjee RK., Gastroprotective effect of Neem(Azadirachta indica) bark extract: possible involvement of H+-K+-ATPase inhibition and scavenging of hydroxyl radical, Life sci, 2002; 71; 2845.
3. Chattopadhyay I, Nandi B, Chatterjee R, Biswas K, Bandyopadhyay U & Banerjee RK., Mechanism of antiulcer effect of Neem (Azadirachta indica) leaf extract: Effect on H+-K+-ATPase, oxidative damageand apoptosis, Inflammopharmacology 2004 ; 12: 153.
4. Chattopadhyay I, Bandyopadhyay U, Biswas K, Maity P & banerjee R K., Indomethacin inactivates gastric Peroxidase to induce reactive-oxygen-mediated gastric mucosal injury and curcumin protects it by preventing peroxidase inactivation and scavenging reactive oxygen, Free radical Biology and Medicine, 2006 ;40: 1397.
5. Chattopadhyay I, Biswas K, Bandopadhyay U & Banerjee RK. Turemeric and curcumin: Biological actions and medicinal applications, Curr Sci, 2004; 87: 44.
6. Cragg GM, Newman DJ & Snader K M. Natural products in Drug discovery and development, J Nat Prod,1997; 60: 52.
7. De Smet PA .The role of plant derived drugs and herbal medicines in healthcare, Drugs, 1997; 54: 801.
8. Shu YZ. Recent natural products based drug development: a pharmacological industry perspective, J Nat Prod1998; 61: 1053.
9. Swarnakar s, Ganguly K, Kundu P Banerjee A, Maity P & sharma AV. Curcumin regulates expression and activity of matrix metalloprotinases 9 and 2 during prevention and healing of indomathacin-induced gastric ulcer. J Biol Chem, 2005; 280: 9409.
10. Pallab M, Dhananjyay H, Uday Bandyopadyay & Mishra DK.. Biological activities of crude extracts and chemical constituents of Bael(Aegle marmelos), Indian journal of Experimental Biology 2009 ; 47: 849-861
11. ICMR. Collaborating center new delhi, flexible dose open trial of vijaysar in case of newly diagnosed non-insulin dependent diabetes mellitus. Indian journal of medical research, 1998; 108: 24-29.

12. Das, AV., Padayatti, PS., Paulose, CS. Effect of leaf extract of *Aegle marmelose* (L.) Correa ex Roxb. on histological and ultrastructural changes in tissues of streptozotocin induced diabetic rats. Indian Journal of Experimental Biology1996; 34: 341–345.
13. Sachdewa, A., Raina, D., Srivastava, AK., Khemani, LD. Effect of *Aegle marmelos* and *Hibiscus rosa sinensis* leaf extract on glucose tolerance in glucose induced hyperglycemic rats (Charles foster). Journal of Environmental Biology . 2001;22: 53–57.
14. Augusti, KT. Studies on the effects of a hypoglycemic principle from *Allium Cepa* Linn. Indian Journal of Medical Research 1973; 61: 1066–1071.
15. Jain, RC., Vyas, CR. Garlic in alloxan-induced diabetic rabbits.American. Journal of Clinical Nutrition 1975;28: 684–685.
16. Rajasekaran, S., Sivagnanam, K., Ravi, K., Subramanian, S. Hypoglycemic effect of *Aloe vera* gel on streptozotocin-induced diabetes in experimental rats. Journal of Medicinal Food. 2004; 7: 61–66.
17. Okyar, A., Can, A., Akev, N., Baktir, G., Sutlupinar, N. Effect of *Aloe vera* leaves on blood glucose level in type I and type II diabetic rat models. Phytotherapy Research. 2001; 15: 157–161.
18. Subramoniam, A., Pushpangadan, P., Rajasekharan, S., Evans, DA., Latha, PG., Valsaraj, R.. Effects of *Artemisia pallens* Wall on blood glucose levels in normal and alloxan-induced diabetic rats. Journal of Ethnopharmacology 1996; 50:13–17.
19. Gupta, RK., Kesari, AN., Murthy, PS., Chandra, R., Tandon, V., Watal, G. Hypoglycemic and hypoglycemic effect of ethanolic extract of leaves of *Annona squamosa* L. in experimental animals. Journal of Ethnopharmacology 2005; 99: 75–81.
20. Yu, BC., Hung, CR., Chen, WC., Cheng, JT. Antihyperglycemic effect of andrographolide in streptozotocin-induced diabetic rats. Planta Medica2003; 69: 1075–1079.
21. Chattopadhyay, R.R. A comparative evaluation of some blood sugar lowering agents of plant origin. Journal of Ethnopharmacology 1999; 67: 367–372.
22. Puri, D. The insulinotropic activity of a Nepalese medicinal plant *Biophytum sensitivum*: preliminary experimental study. Journal of Ethnopharmacology 2001;78: 89–93.
23. Puri, D., Baral, N. Hypoglycaemic effect of *Biophytum sensitivum* in the alloxan diabetic rabbits. Indian Journal of Physiology and Pharmacology1998; 42: 401–406.
24. Yoshikawa, M., Murakami, T., Kadoya, M., Matsuda, H., Muraoka, O., Yamahara, J., Murakami, N. Medicinal foodstuff. III. Sugar beet. Hypoglycemic oleanolic acid oligoglycosides, betavulgarosides I, II, III, and IV, from the root of *Beta vulgaris* L. (Chenopodiaceae). Chemical and pharmaceutical Bulletin (Tokyo) 1996; 44: 1212–1217.
25. Khan, BA., Abraham, A., Leelamma, S. Hypoglycemic action of *Murraya koeingii* (curry leaf) and *Brassica juncea* (mustard): mechanism of action. Indian Journal of Biochemistry and Biophysics 1995;32: 106–108.
26. Satheesh, MA., Pari, L Antioxidant effect of *Boerhavia diffusa* L. in tissues of alloxan induced diabetic rats. Indian Journal of Experimental Biology. 2004; 42: 989–992.
27. Satheesh, MA., Pari, L. Antioxidant effect of *Boerhavia diffusa* L. in tissues of alloxan induced diabetic rats. Indian Journal of Experimental Biology. 2004; 42: 989–992.
28. Chude, MA., Orisakwe, OE., Afonne, OJ., Gamaniel, KS., Vongtau, OH ,Obi, E. Hypoglycaemic effect of the aqueous extract of *Boerhavia diffusa* leaves. Indian Journal of Pharmacology2001; 33: 215–216
29. Abesundara, KJ., Matsui, T., Matsumoto, K.. Alpha-glucosidase inhibitory activity of some Sri Lanka plant extracts, one of which, *Cassia auriculata*, exerts a strong antihyperglycemic effect in rats comparable to the therapeutic drug acarbose. Journal of Agricultural and Food Chemistry2004; 52: 2541–2545.

30. Latha, M., Pari, L. Preventive effects of *Cassia auriculata* L. flowers on brain lipid peroxidation in rats treated with streptozotocin. Molecular and Cellular Biochemistry 2003; 243: 23–28.
31. Sharma, SR., Dwivedi, SK., Swarup, D. Hypoglycemic, antihyperglycemic and hypolipidemic activities of *Caesalpinia bonducella* seeds in rats. Journal of Ethnopharmacology 1997; 58: 39–44.
32. Chakrabarti, S., Biswas, TK., Seal, T., Rokeya, B., Ali, L., Azad Khan, AK., Nahar, N., Mosihuzzaman, M., Mukherjee, B. Hypoglycemic 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. Journal of Ethnopharmacology 2005;97: 117–122.
33. Chakrabarti, S., Biswas, TK., Rokeya, B., Ali, L., Mosihuzzaman, M., Nahar, N., Khan, AK., Mukherjee, B. Advanced studies on the hypoglycemic effect of *Caesalpinia bonducella* F. in type 1 and 2 diabetes in Long Evans rats. Journal of Ethnopharmacology 2003;84: 41–46.
34. Esposito Avella, M., Diaz, A., de Gracia, I., de Tello, R., Gupta, MP. Evaluation of traditional medicine: effects of *Cajanus cajan* L. and of *Cassia fistula* L. on carbohydrate metabolism in mice. Revista Medica de Panama 1991; 16: 39–45.
35. Panlasigui, LN., Panlilio, LM., Madrid, JC. Glycemic response in normal subjects to five different legumes commonly used in the Philippines. International Journal of Food Science and Nutrition1995; 46:155–160.
36. Al-Ghaithi, F., El-Ridi, MR., Adeghate, E., Amiri, M.H. 1995. Biochemical effects of *Citrullus colocynthis* in normal and diabetic rats. Molecular and Cellular Biochemistry 1995;261: 143–149.
37. Kamble, SM., Kamlakar, PL., Vaidya, S., Bambole, VD. Influence of *Coccinia indica* on certain enzymes in lycolytic and lipolytic pathway in human diabetes. Indian Journal of Medical Science1998; 52: 143–146.
38. Shibib, BA., Khan, LA., Rahman, R. Hypoglycemic activity of *Coccinia indica* and *Momordica charantia* in diabetic rats: depression of the diabetic mice. Journal of Asian Natural Product Research1993; 2: 321– 327.
39. Platel, K., Srinivasan, K. Plant foods in the management of diabetes mellitus: vegetables as potential hypoglycemic agents. Die Nahrung. 1997; 41:68–74.
40. Azad Khan, AK., Akhtar, S., Mahtab, H. *Coccinia indica* in the treatment of patients with diabetes mellitus. Bangladesh Medical Research Council Bulletin 1979;5: 60–66.
41. Prakasam, A., Sethupathy, S., Pugalendi, KV. Antihyperglycaemic effect of *Casearia esculenta* root extracts in streptozotocin-induced diabetic rats. Pharmazie2002; 57; 758–760.
42. Singh, SN., Vats, P., Suri, S., Shyam, R., Kumria, MM., Ranganathan, S., Sridharan, K.. Effect of an hypoglycemic extract of *Catharanthus roseus* on enzymic activities in streptozotocin induced diabetic rats. Journal of Ethnopharmacology 2001; 76: 269–277.
43. Chattopadhyay, RR., Sarkar, SK., Ganguly, S., Banerjee, RN., Basu, TK.. Hypoglycemic and antihyperglycemic effect of leaves of *Vinca rosea* Linn. Indian Journal of Physiology and Pharmacology1991; 35: 145– 151.
44. Anderson, RA., Polansky MM. Tea enhances insulin activity. Journal of Agricultural and Food Chemistry 2002; 50, 7182–7186.
45. Gomes, A., Vedasiromoni, JR., Das, M., Sharma, RM., Ganguly, DK. Anti-hyperglycemic effect of black tea (*Camellia sinensis*) in rat. Journal of Ethnopharmacology1995; 45: 223–226.
46. Srinivasan, M., Padmanabhan, M., Prince, PS. Effect of aqueous *Enicostemma littorale* Blume extract on key carbohydrate metabolic enzymes, lipid peroxides and antioxidants in alloxan-induced diabetic rats. Journal of Pharmcy and Pharmacology2005; 57: 497–503.
47. Maroo, J., Vasu, VT., Aalinkeel, R., Gupta.S. Glucose lowering effect of aqueous extract of *Enicostemma littorale* Blume in diabetes: a possible mechanism of action. Journal of Ethnopharmacology2002; 81: 317– 320.

48. Murali, B., Upadhyaya, UM., Goyal, RK. Effect of chronic treatment with *Enicostemma littorale* in non-insulin-dependent diabetic (NIDDM) rats. Journal of Ethnopharmacology2002; 81: 199–204.
49. Ravi, K., Ramachandran, B., Subramanian, S. Protective effect of *Eugenia jambolana* seed kernel on tissue antioxidants in streptozotocininduced diabetic rats. Biological and Pharmaceutical Bulletin2004; 27: 1212–1217.
50. Kumar, RV., Augusti, KT. Hypoglycemic effect of a leucocyanidin derivative isolated from the bark of *Ficus bengalensis* Linn. Indian Journal of Biochemistry and Biophysics1989; 26: 400–404.
51. Sachdewa, A., Nigam, R., Khemani, L.D. Hypoglycemic effect of *Hibiscus rosa sinensis* L. leaf extract in glucose and streptozotocin induced hyperglycemic rats. Indian Journal of Experimental Biology2001b; 39:284–286.
52. Sachdewa, A., Khemani, LD. A preliminary investigation of the possible hypoglycemic activity of *Hibiscus rosa-sinensis*. Biomedical and Environmental Sciences1999; 12: 222–226.
53. Chakrabarti, R., Vikramadithyan, RK., Mullangi, R., Sharma, VM., Jagadheshan, H., Rao, YN., Sairam, P., Rajagopalan, R. Hypoglycemic and hypolipidemic activity of *Helicteres isora* in animal models. Journal of Ethnopharmacology 2002; 81: 343–349.
54. Venkatesh, S., Dayanand Reddy, G., Reddy, Y.S., Sathyavathy, D., Madhava Reddy, B. Effect of *Helicteres isora* root extracts on glucose tolerance in glucose-induced hyperglycemic rats. Fitoterapia2004; 75: 364– 367.
55. Aderibigbe, A.O., Emudianughe, T.S., Lawal, BA. Antihyperglycaemic effect of *Mangifera indica* in rat. Phytotherapy Research 1999; 13: 504–507.
56. Murugananda S, Srinivasan K., Gupta, S, Gupta, PK., Lal, J. Effect of Mangifera indica on hyperglycemia and atherogenicity in streptozotocin diabetic rats. Journal of Ethnopharmacology2005; 97: 497–501.
57. Rathi SS, Grover JK. Vats V. The effect of *Momordica charantia* and *Mucuna pruriens* in experimental diabetes and their effect on key metabolic enzymes involved in carbohydrate metabolism. Phytotherapy Research2002; 16: 236–243
58. Grover JK., Vats V, Rathi SS, Dawar R. Traditional Indian antidiabetic plants attenuate renal hypertrophy, urine volume and albuminuria in streptozotocin induced diabetic mice. Journal of Ethnopharmacology2001; 76: 233–238.
59. Akhtar MS, Qureshi AQ, Iqbal J. Hypoglycemic evaluation of *Mucuna pruriens* Linn. seeds. Journal of Pakistan Medical Association 1990;40: 147–150.
60. Chen, F, Nakashima N, Kimura I, Kimura M. Hypoglycemic activity and mechanisms of extracts from mulberry leaves (*Folium mori*) and cortex mori radicis in streptozotocin-induced diabetic mice. Yakugaku Zasshi1995; 115: 476–482.
61. Iyer UM, Mani UV. Studies on the effect of curry leaves supplementation (*Murraya koeingii*) on lipid profile, glycated proteins and amino acids in non-insulin-dependent diabetic patients. Plant Foods and Human Nutrition1990; 40: 275–282.
62. Khan BA., Abraham A, Leelamma S. Hypoglycemic action of *Murraya koeingii* (curry leaf) and *Brassica juncea* (mustard): mechanism of action. Indian Journal of Biochemistry and Biophysics 1995;32: 106–108.
63. Vats V, Yadav SP, Grover JK. Ethanolic extract of *Ocimum sanctum* leaves partially attenuates streptozotocin-induced alterations in glycogen content and carbohydrate metabolism in rats. Journal of Ethnopharmacology2004a; 90: 155–16
64. Rai V, Iyer U, Mani UV. Effect of Tulsi (*Ocimum sanctum*) leaf powder supplementation on blood sugar levels, serum lipids and tissue lipids in diabetic rats. Plant Foods and Human Nutrition 1997; 50: 9–16.

65. Das, AK., Mandal SC, Banerjee SK., Sinha S, Saha BP, Pal M. Studies on the hypoglycaemic activity of *Punica granatum* seed in streptozotocin induced diabetic rats. Phytotherapy Research2001; 15: 628–629.
66. Jafri, MA., Aslam, M., Javed, K., Singh, S. Effect of *Punica granatum* Linn. (flowers) on blood glucose level in normal and alloxan-induced diabetic rats. Journal of Ethnopharmacology2000; 70: 309–314.
67. Jayawardena, MH, de Alwis, NM., Hettigoda V., Fernando, DJ. A double blind randomised placebo controlled cross over study of a herbal preparation containing *Salacia reticulata* in the treatment of type 2 diabetes. Journal of Ethnopharmacology2005; 97: 215–218.
68. Karunanayake, EH, Welihinda, J., Sirimanne, SR., Sinnadorai, G. Oral hypoglycemic activity of some medicinal plants of Sri Lanka. Journal of Ethnopharmacology1984; 11: 223–231.
69. Yoshikawa, M., Murakami, T., Yashiro, K., Matsuda, H. Kotalanol, a potent alpha-glucosidase inhibitor with thiosugar sulfonium sulfate structure, from hypoglycemic Ayurvedic medicine *Salacia reticulata*. Chemical and Pharmaceutical Bulletin (Tokyo)1998; 46: 1339–1340.
70. Heacock, PM., Hertzler SR, Williams JA., Wolf BW. Effects of a medical food containing an herbal alpha-glucosidase inhibitor on postprandial glycemia and insulinemia in healthy adults. Journal of the American Diabetic Association 2005;105: 65–71.
71. Saxena, A.M., Bajpai, MB., Murthy, PS., Mukherjee, SK.. Mechanism of blood sugar lowering by a Swerchirin-containing hexane fraction (SWI) of *Swertia chirayita*. Indian Journal of Experimental Biology1993; 31: 178–181.
72. Saxena, A.M., Bajpai, M.B., Mukherjee, S.K. Swerchirin induced blood sugar lowering of streptozotocin treated hyperglycemic rats. Indian Journal of Experimental Biology1991; 29: 674–675.
73. Chandrasekar, B., Bajpai, M.B., Mukherjee, SK.. Hypoglycemic activity of *Swertia chirayita* (Roxb ex Flem) Karst. Indian Journal of Experimental Biology1990; 28: 616–618.
74. Sekar, BC., Mukherjee, B., Chakravarti, RB., Mukherjee, SK. Effect of different fractions of *Swertia chirayita* on the blood sugar level of albino rats. Journal of Ethnopharmacology1987; 21: 175–181.
75. Latha, M., Pari, L., Sitasawad, S., Bhonde, R. Insulin-secretagogue activity and cytoprotective role of the traditional hypoglycemic plant *Scoparia dulcis* (Sweet Broomweed). Life Science2004; 75; 2003–2014.
76. Pari, L., Venkateswaran, S. Hypoglycaemic activity of *Scoparia dulcis*L. extract in alloxan induced hyperglycaemic rats. Phytotherapy Research 2002; 16: 662–664.

Source of support: Nil, Conflict of interest: None Declared