IJPSR (2012), Vol. 3, Issue 1 **(Research Article)**

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 16 September, 2011; received in revised form 20 October, 2011; accepted 29 December, 2011

ANTIHYPERGLYCEMIC, ANTIOXIDANT AND ANTIDYSLIPIDEMIC PROPERTIES OF *HEMIDESMUS INDICUS* ROOT EXTRACT STUDIED IN ALLOXAN-INDUCED EXPERIMENTAL DIABETES IN RATS

S. Subramanian*, A. Abarna and V. Thamizhiniyan

Department of Biochemistry, University of Madras, Guindy campus, Chennai-600 025, Tamil Nadu, India

Keywords:
Diabetes, alloxan, *Hemidesmus indicus*, Antihyperglycemic, Antidyslipidemic

Correspondence to Author:

Dr. S. Subramanian

Assistant Professor, Department of Biochemistry, University of Madras, Guindy campus, Chennai-600 025, Tamil Nadu, India

ABSTRACT

Diabetes mellitus is a chronic metabolic disorder associated with hyperglycemia, oxidative stress and dyslipidemia. *Hemidesmus indicus* is employed as an indigenous medicine for a variety of ailments from earlier days. The present study was aimed to evaluate the role of *Hemidesmus indicus* in alloxan-induced experimental diabetic rats. The effect of oral administration of *Hemidesmus indicus* root extract (400 mg/kg b.w.) on glucose tolerance, the levels of blood glucose, hemoglobin, glycosylated hemoglobin, plasma insulin, protein, lipid peroxides, enzymatic and non-enzymatic antioxidants, lipid profile, muscle glycogen content were determined in control and experimental groups of rats. The altered levels of blood glucose, hemoglobin, glycosylated hemoglobin, plasma insulin, and protein in the diabetic rats were significantly reverted back to near basal values by the administration of ethanol extract of *Hemidesmus indicus* root to diabetic rats for 30 days. The levels of lipid peroxides in the plasma and pancreatic tissues of diabetic rats were elevated significantly and were normalized by the administration of *Hemidesmus indicus* root extract. The activities of pancreatic enzymic antioxidants and the levels of plasma non-enzymic antioxidants were markedly declined in the diabetic rats. Upon treatment with *Hemidesmus indicus* root extract to diabetic rats, these decreased levels were elevated to near normal values. The reduced level of glycogen content in muscle tissues of diabetic rats was significantly improved upon treatment with *Hemidesmus indicus* root extract. The altered levels of lipid profile were reverted back to near normalcy upon the extract treatment. The results of the study indicate that *Hemidesmus indicus* root extract possesses antihyperglycemic, antioxidant and antidyslipidemic activity. The results are comparable with glyclazide, an oral standard hypoglycemic drug. The phytochemicals present in the *Hemidesmus indicus* root extract may account for the observed pharmacological properties.

INTRODUCTION: Diabetes mellitus is a chronic metabolic disorder associated with abnormalities in carbohydrate, lipid and protein metabolism. The unprecedented economic development and rapid urbanization in Asian countries, particularly in India has led to a shift in health problems from communicable to non-communicable diseases. Diabetes mellitus has emerged as one of the main alarms to human health in the 21st century. Individuals with diabetes are at risk for a multitude of metabolic abnormalities that leads to microvascular and macrovascular complications, with cardiovascular disease being the leading cause of

mortality in these patients [1]. Although several therapies are in use for the treatment of diabetes mellitus, there are certain limitations due to side effects such as development of hypoglycemia, weight gain, gastrointestinal disturbances, and hepatotoxicity [2].

So, the need of phytotherapy for the treatment of diabetes serves as an ideal target. *Hemidesmus indicus* commonly known as Indian sarsaparilla grows over the greater parts of India. Indian sarsaparilla is widely recognized in folk medicine and an ingredient in ayurvedic and unani preparations against disease of biliousness, blood diseases, diarrhea, skin diseases, respiratory diseases, bronchitis, eye diseases, burning sensation, rheumatism and gastric disorders [3].

Root decoction helps in skin diseases, elephantiasis, loss of appetite, blood purification and for kidney as well as urinary disorders. It has also been used in combination with other drugs for snake bite [4]. In the absence of systematic studies in literature, the present study is aimed to evaluate the role of Hemidesmus indicus root extract in alloxan-induced experimental diabetes in rats.

MATERIALS AND METHODS:

Plant Material: The roots of *Hemidesmus indicus* were collected from Tenkasi, Tirunelveli District. The plants were identified and authenticated and a voucher specimen was deposited at the Department of Botany, University of Madras, Chennai.

Preparation of Plant extract: The *Hemidesmus indicus* roots were dried at room temperature and powdered in an electrical grinder, which was then stored in an airtight container at 5°C until further use. The powdered root was delipidated with petroleum ether (60 - 80° C) for overnight. It was then filtered and soxhalation was performed with 95% Ethanol. Ethanol was evaporated in a rotary evaporator at 40 – 50° C under reduced pressure.

Phytochemical screening: The ethanolic extract of *Hemidesmus indicus* roots were subjected to preliminary phytochemical screening of various plant constituents [5, 6].

Experimental Animals: Male albino Wistar rats (150-180 g) were purchased from TANUVAS, Madavaram, Chennai. The rats were housed in polypropylene cages lined with husk and kept in animal house, Department of Biochemistry. The rats were fed with commercial pelleted rats chow (VRK Nutritional Solutions, Maharashtra, India) and had free access to water. The experimental rats were maintained in a controlled environment (12:12 hours light/dark cycle) and temperature (30 ± 2°C).

The experiments were designed and conducted in accordance with the ethical norms approved by Ministry of Social Justices and Empowerment, Government of India and Institutional Animal Ethics Committee Guidelines for the investigation of experimental pain in conscious rats. The rats were acclimatized for one week before starting the experiments.

Induction of Diabetes Mellitus: Experimental diabetes was induced in overnight fasted rats by single intraperitoneal injection of alloxan monohydrate dissolved in sterile normal saline at a dose 120 mg/Kg body weight. After 1 hour of alloxan administration, the animals were fed with standard pellets and water *ad libitum*. Rats were supplied with 5% Glucose solution for 48 hours after alloxan injection in order to prevent severe hypoglycaemia. After 1 week time, the rats having persistent glycosuria and hyperglycemia (Blood glucose range of above 250 mg/dL) were considered as diabetic rats and used for the experiment. The treatment was started on the eighth day after alloxan injection and this was considered as first day of treatment.

Experimental Design: The rats were grouped into 4 groups, comprising of 6 rats in each group as follows:

Group I	:	Control rats
Group II	:	Alloxan induced diabetic rats
Group III	:	Diabetic rats treated with *Hemidesmus indicus* root extract (400 mg/Kg body weight/rat/day) in aqueous solution orally for 30 days.
Group IV	:	Diabetic rats treated with gliclazide (5mg/Kg body weight/rat/day) in aqueous solution orally for 30 days.

Oral Glucose Tolerance Test (OGTT): OGTT was performed on 28th day of the experimental period. Prior to an OGTT, all the rats were fasted overnight and then rats were loaded with glucose (2 g/ Kg body weight) in aqueous solution with a feeding syringe. Blood samples were collected from the tail vein just prior to the administration of glucose and at 30, 60, 90 and 120 min after glucose loading. The level of glucose in all blood samples was measured by the method of Trinder (1969) [7].

At the end of the experimental period, the rats were fasted over night, anaesthetized, and sacrificed by cervical decapitation. The blood was collected with and without anticoagulant for plasma and serum separation respectively.

Whole blood was used for estimation of glycosylated hemoglobin according to the method of Nayak and Pattabiraman (1981) [8]. Blood glucose was estimated according to the method of Trinder (1969) [7], insulin assay using commercial ELISA kit for rats. Levels of vitamin C, vitamin E and reduced glutathione (GSH) in plasma were determined by the methods of Omaye *et al*. (1979) [9], Desai (1984) [10], and Sedlak and Lindsay (1968) [11], respectively.

Pancreatic tissues were selectively excised, washed in ice-cold saline and then homogenized in Tris- HCl buffer (pH 7.4) using a Teflon homogenizer. The pancreatic tissue homogenates were then centrifuged at 5000 g to remove cellular debris and supernatant was used for the determination of lipid peroxides and activity of enzymatic antioxidants. Lipid peroxides was determined using thiobarbituric acid by the method of Ohkawa *et al*. (1979) [12]. Enzymatic antioxidants such as superoxide dismutase (Misra and Fridovich, 1972) [13], catalase (Takahara *et al*., 1960) [14], and glutathione peroxidase (Rotruck *et al*., 1973) [15] in pancreas were assayed.

Hind limb muscles tissues from all groups of rats were excised, washed in ice-cold saline and the level of glycogen content was determined by the method of Morales *et al*. (1973) [16].

The levels of lipids in plasma were also estimated. Cholesterol content was estimated by the method of Parekh and Jung (1970) [17]. Triglyceride was estimated by the method of Rice (1970) [18]. HDL-Cholesterol fraction was separated by the precipitation techniques of Burstein and Scholnick (1972) [19] and the cholesterol content was determined by method of Parekh and Jung (1970) [17].

Statistical analysis: All the grouped data were statistically evaluated with SPSS 16.00 software. Hypothesis testing methods included one-way analysis of variance followed by least significant difference (LSD) test. $p<0.05$ was considered to indicate statistical significance. All results are expressed as mean ± standard deviation (SD) for six rats in each group.

RESULTS AND DISCUSSION: Table 1 shows the qualitative analysis of phytochemicals in the ethanolic extract of *Hemidesmus indicus* root. Phytochemical evaluation revealed the presence of phenols, alkaloids, flavonoids, glycosides, saponins, tannins, phytosterols and terpenoids indicating the role of these phytochemicals in the observed effect.

TABLE 1: PHYTOCHEMICAL SCREENING OF *HEMIDEMUS INDICUS* ROOTS EXTRACT

PHYTOCONSTITUENTS	INFERENCE
Phenols	+
Alkaloids	+
Flavonoids	+
Glycosides	+
Saponins	+
Tannins	+
Phytosterol	+
Terpenoids	+
Anthraquinones	-

Alloxan commonly known to be a β-cytotoxin induces 'diabetes' in a wide variety of animal species by damaging the insulin secreting cells of the pancreas (Szkudelski, 2001) [20]. This damages a large number of beta cells, resulting in the decrease in endogenous insulin release, which paves the ways for the decreased utilization of glucose by the insulin dependent tissues lead to persistent hyperglycemia. **Figure 1** shows the changes in the levels of blood glucose, before and after oral administration of glucose (2g/Kg) in normal control and experimental group of rats. The data of OGTT revealed that the blood glucose value in normal control rat reached peak at 60 minutes after the oral glucose load and gradually reverted back to near normal levels over the next 60

minutes. In diabetic control rats, the peak increase in blood glucose concentration was observed in 60 minutes and remained high over the next 60 minutes. *Hemidesmus indicus* root extract as well as gliclazide treated groups showed definite lower peak blood glucose values, and was returned back to near basal level at the end of 120 minutes.

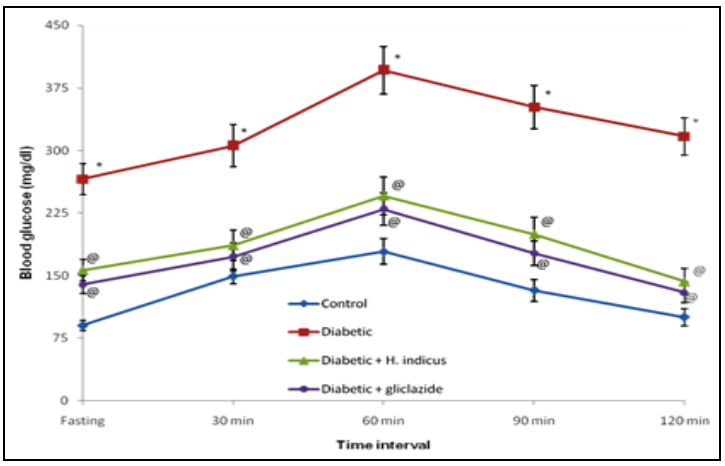

FIG. 1: EFFECT OF *HEMIDESMUS INDICUS* ROOT EXTRACT ON THE BLOOD GLUCOSE LEVEL IN THE EXPERIMENTAL GROUPS OF RATS AFTER RECEIVING AN ORAL GLUCOSE (2 g/kg) LOAD

Values are given as mean ± SD for groups of six rats in each. Values are statistically significant at $p < 0.05$. Statistical significance was compared within the groups as follows: *compared with control, @ compared with diabetic rats.

Figure 2 represents the level of glycogen content in muscle tissues of control and experimental groups of rats. A significant decline in the glycogen level was noted in the muscle tissues of diabetic group of rats. Oral treatment with *Hemidesmus indicus* root extract as well as gliclazide to diabetic rats restored the level of glycogen to near normalcy when compared to diabetic group of rats and this indicates the improved utilization of glucose by the peripheral tissues.

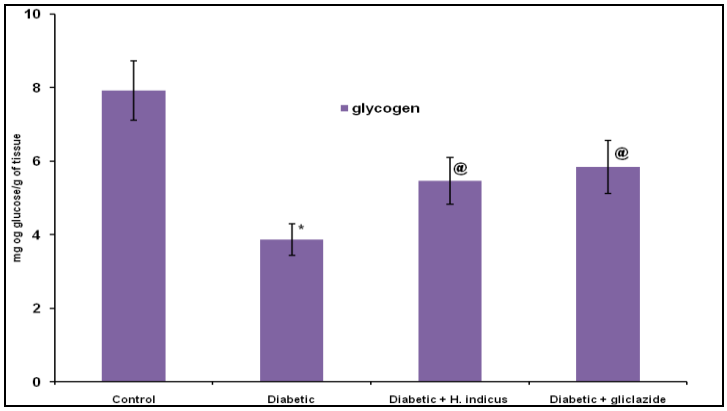

FIG. 2: EFFECT OF *H. INDICUS* EXTRACT ON THE LEVELS OF MUSCLE GLYCOGEN CONTENT IN THE EXPERIMENTAL GROUPS OF RATS

Values are given as mean ± SD for groups of six rats in each. Values are statistically significant at $p < 0.05$. Statistical significance was compared within the groups as follows: *compared with control, @ compared with diabetic rats.

The effect of oral administration of *Hemidesmus indicus* root extract on the levels of blood glucose, plasma insulin, glycosylated hemoglobin and urine sugar in the experimental groups of rats were depicted in **Table 2**. In alloxan induced diabetic rats, there was a significant decrease in the level of insulin when compared with normal control rats. Administration of *Hemidesmus indicus* root extract as well as the standard drug, gliclazide to diabetic rats reverted the levels to near normal as control rats. The elevation in plasma insulin in the extract treated diabetic rats could be because of the protection of the remnant functional β-cells by the phytoconstituents present in the *Hemidesmus indicus* roots extract.

During diabetes, the excess glucose present in the blood reacts with hemoglobin to form glycosylated hemoglobin. So the level of glycosylated hemoglobin is directly proportional to the blood glucose level over 2 to 3 month period [21]. In the present study, diabetic rats showed higher levels of glycosylated hemoglobin indicating their poor glycemic control. Treatment with *Hemidesmus indicus* root extract showed a significant decrease in the glycosylated hemoglobin level, which could be due to an improvement in glycemic control. Thus, the reduction of HbA_1c levels by *Hemidesmus indicus* roots extract indicates its antihyperglycemic activity, since the concentration of HbA_1c is more parallel to the observed blood glucose concentrations.

Table 3 depicts the activity of enzymatic antioxidants such as superoxide dismutase, catalase and glutathione peroxidase in the pancreas of control and experimental groups of rats. The antioxidant enzymes such as SOD, CAT and GPx are some of the biological antioxidants that directly scavenge the free radicals or prevent their conversion to toxic products [22]. Diabetes is associated with the altered activity of these enzymes that results in an increased oxidative stress. The enhanced oxidative stress and changes in an antioxidant potential observed in both clinical and experimental diabetes mellitus are thought to be the contributor for the progression of diabetic complications.

TABLE 2: EFFECT OF *HEMIDESMUS INDICUS* ROOT EXTRACT ON THE LEVELS OF BLOOD GLUCOSE, PLASMA INSULIN, GLYCOSYLATED HEMOGLOBIN AND URINE SUGAR IN THE EXPERIMENTAL GROUPS OF RATS

Groups	Glucose (mg/dl)	Insulin (µU/ml)	Glycosylated hemoglobin (%)	Urine sugar
Control	97.59 ± 10.25	15.98 ± 2.75	6.57 ± 1.62	Nil
Diabetic	299.78 ± 22.46*	5.74 ± 1.02*	13.28 ± 2.79*	+++
Diabetic + *H. indicus*	148.32 ± 12.54[@]	10.51 ± 2.45[@]	8.12 ± 1.91[@]	Nil
Diabetic + gliclazide	124.12 ± 16.27[@]	12.14 ± 1.98[@]	7.85 ± 2.04[@]	Nil

Values are given as mean ± SD for groups of six rats in each. Values are statistically significant at $p < 0.05$. Statistical significance was compared within the groups as follows: *compared with control, [@] compared with diabetic rats.

SOD is an important defense enzyme, scavenges O_2^- to form H_2O_2 and hence diminishes the toxic effects due to this radical or other free radicals derived from secondary reaction [23]. The observed decrease in SOD activity in pancreas of diabetic rats could result from inactivation by H_2O_2 or by glycation of enzymes [24]. Catalase is largely located in subcellular organelles known as peroxisomes. CAT is a hemoprotein which catalyzes the reduction of hydrogen peroxides and known to be involved in detoxification of H_2O_2 concentrations [23, 25]. Reduced activity of SOD and CAT in many tissues has been observed during diabetes and this may result in a number of deleterious effects due to the accumulation of superoxide radicals and hydrogen peroxide.

In the present study, SOD and catalase assay shows that the diabetic rats had a decreased activity which when treated with *Hemidesmus indicus* roots extract and gliclazide showed a gradual increasing activity as of near normal range. Glutathione peroxidase (GPx) is a selenoprotein, first described as an enzyme that protects hemoglobin from oxidative degradation in red blood cells. GPx plays a primary role in minimizing oxidative damage. Reduced activities of GPx may result from radical induced inactivation and glycation of the enzyme [26]. In the present study, glutathione peroxidase assay shows that the diabetic rats had a decreased activity which when treated with *Hemidesmus indicus* roots extract and gliclazide showed a increasing activity as of near normal range.

TABLE 3: EFFECT OF *H. INDICUS* EXTRACT ON THE ACTIVITY OF SOD, CATALASE AND GPX, IN PANCREAS OF EXPERIMENTAL GROUPS OF RATS

Groups	SOD	Catalase	GPx
Control	5.26 ± 1.25	15.42 ± 2.09	6.27 ± 1.02
Diabetic	1.39 ± 0.41*	5.83 ± 1.40*	3.10 ± 0.32*
Diabetic + *H. indicus*	3.81 ± 0.92[@]	12.25 ± 1.87[@]	4.76 ± 0.65[@]
Diabetic + gliclazide	3.99 ± 0.86[@]	13.02 ± 1.98[@]	5.40 ± 0.92[@]

Activity is expressed as: 50% of inhibition of epinephrine auto-oxidation/min/mg of protein for SOD; µmoles of hydrogen peroxide decomposed/min/mg of protein for catalase; µmoles of glutathione oxidized/min/mg of protein for GPx; mg/100 g tissue for GSH. Values are given as mean ± SD for groups of six rats in each. Values are statistically significant at $p < 0.05$. Statistical significance was compared within the groups as follows: *compared with control, [@] compared with diabetic rats.

The effect of *Hemidesmus indicus* root extract on the plasma levels of non-enzymatic antioxidants such as vitamin C, vitamin E and reduced glutathione in the experimental groups of rats are shown in **Table 4**.

Vitamin C and vitamin E, often referred to as "antioxidant vitamins" that have been suggested to limit oxidative damage in humans and lower the risk of certain chronic diseases such as diabetes mellitus. Vitamin C is a key antioxidant that particularly protects the lipids from peroxidative damage. Vitamin C cooperates with Vitamin E to regenerate α-tocopherol from α-tocopherol radicals in membranes and lipoproteins and also raises intracellular glutathione levels thus playing an important role in protein thiol group protection against oxidation [27, 28]. The reduced concentration of vitamin C in blood may arise due to the excessive oxidation and lack of regeneration from their radical form to reduced form [29].

Vitamin E is a lipophilic antioxidant and inhibits lipid peroxidation, scavenging lipid peroxyl radicals to yield lipid hydroperoxides and the alpha-tocopheroxyl radicals [30]. During the antioxidant reaction, α-tocopherol is converted to α-tocopherol radical by the donation of labile hydrogen to a lipid or lipid peroxyl radical, and the α-tocopherol radical can therefore be reduced to the original α-tocopherol form by ascorbic acid [27]. Reduced glutathione (GSH) is a strong antioxidant involved in many metabolic pathways.

Reduced glutathione plays an important role in the detoxification of xenobiotic compounds and in the auto-oxidation of reactive species and free radicals [31].

In the present study, administration of *Hemidemus indicus* root extract and gliclazide to the diabetic rats resulted in a marked increase in the levels of these non-enzymatic antioxidants suggesting the free radical scavenging potential of *Hemidesmus indicus* root extract.

TABLE 4: EFFECT OF *H. INDICUS* EXTRACT ON THE LEVELS OF VITAMIN C, VITAMIN E AND GSH IN PLASMA OF EXPERIMENTAL GROUPS OF RATS

Groups	Vitamin C	Vitamin E	GSH
Control	1.49 ± 0.15	0.69 ± 0.09	30.74 ± 3.99
Diabetic	0.50 ± 0.09*	0.32 ± 0.04*	14.99 ± 2.45*
Diabetic + *H. indicus*	0.98 ± 0.12[@]	0.55 ± 0.07[@]	22.86 ± 2.87[@]
Diabetic + gliclazide	1.02 ± 0.14[@]	0.59 ± 0.05[@]	25.15 ± 3.06[@]

Units: mg/dl. Values are given as mean ± SD for groups of six rats in each. Values are statistically significant at $p < 0.05$. Statistical significance was compared within the groups as follows: *compared with control, [@] compared with diabetic rats.

Table 5 represents the effect of *Hemidesmus indicus* root extract on the levels of lipid peroxides in the plasma and pancreas of experimental groups of rats. Lipid peroxidation (LPO) is enhanced due to an increased oxidative stress in diabetic condition. Lipid peroxidation products such as MDA are generated under high levels of un-scavenged free radicals and may bring about protein damage and inactivation of membrane bound enzymes and thus, they play an important role in pancreatic damage associated with diabetes.

The increase in the levels of lipid peroxides in plasma is thought to be the consequence of increased production and liberation into the circulation of tissue lipid peroxides due to pathological changes [32]. Induction of diabetes in rats uniformly results in an increase in the lipid peroxidation (TBARS), an indirect evidence of intensified free radical production [33]. Increased LPO impairs membrane function by decreasing membrane fluidity and changing the activity of membrane bound enzymes and receptors [34].

Lipid peroxides mediated tissue damage has been observed in the development of both type 1 and type 2 diabetes [35]. The increased concentration of lipid peroxides in plasma and pancreatic tissues of diabetic rats indicates detonated production of free radicals. The elevated levels of TBARS in diabetic rats were reduced significantly to near-normal levels upon treatment with *Hemidesmus indicus*.

TABLE 5: EFFECT OF *H. INDICUS* EXTRACT ON THE LEVEL OF TBARS IN PLASMA AND PANCREAS OF EXPERIMENTAL GROUPS OF RATS

Groups	TBARS	
	Plasma	Pancreas
Control	4.17 ± 0.69	40.24 ± 4.75
Diabetic	8.12 ± 1.61*	78.26 ± 9.44*
Diabetic + *H. indicus*	5.29 ± 1.16[@]	58.29 ± 6.81[@]
Diabetic + gliclazide	5.04 ± 1.02[@]	55.99 ± 7.43[@]

Units: mM/100 g in tissues; nM/ml in plasma. Values are given as mean ± SD for groups of six rats in each. Values are statistically significant at $p < 0.05$. Statistical significance was compared within the groups as follows: *compared with control, [@] compared with diabetic rats.

The levels of total cholesterol, triglycerides, HDL-cholesterol and LDL-cholesterol in control and experimental groups of rats are shown in Table 6. Diabetes is associated with the profound alterations in the lipid and lipoprotein profile as well as an increased risk of premature atherosclerosis, coronary insufficiency and myocardial infarction [36]. The increased level of serum lipids in diabetic subjects is mainly due to the increased mobilization of free fatty acids from peripheral deposits [37].

Rajalingam *et al.,* (1993) has reported that variety of derangements in metabolic and regulatory mechanisms due to insulin deficiency is responsible for the observed accumulation of lipids [38]. Bopanna *et al.* (1997) have also reported the hypolipidaemic effect of the cell culture derived *Hemidesmus indicus* [39]. Several studies have also reported that the reduction in plasma HDL cholesterol in diabetic rats and diabetic patients are due to a defect in reverse cholesterol transport [40].

In the present study, a marked prevention in the alteration of lipid profile by a treatment with *Hemidesmus indicus* roots extract to diabetic animals was observed. This could be the possibility for normalization of the rate of lipogenesis and lipolysis by *Hemidesmus indicus* in a way similar to the effect of insulin on lipid metabolism.

TABLE 6: EFFECT OF *H. INDICUS* EXTRACT ON THE LEVELS OF TOTAL CHOLESTEROL, TRIGLYCERIDES, LDL-CHOLESTEROL AND HDL-CHOLESTEROL IN THE PLASMA OF EXPERIMENTAL GROUPS OF RATS

Groups	Total cholesterol	Triglycerides	LDL	HDL
Control	86.71 ± 10.54	62.39 ± 9.56	50.21 ± 5.52	29.69 ± 2.18
Diabetic	168.12 ± 19.75*	150.87 ± 15.67*	125.35 ± 9.51*	14.54 ± 1.52*
Diabetic + *H. indicus*	106.57 ± 15.78$^{@}$	89.14 ± 10.25$^{@}$	72.79 ± 7.42$^{@}$	21.13 ± 1.98$^{@}$
Diabetic + gliclazide	95.28 ± 12.52$^{@}$	82.46 ± 8.59$^{@}$	60.97 ± 6.69$^{@}$	24. 51 ± 2.09$^{@}$

Units: mg/dl. Values are given as mean ± SD for groups of six rats in each. Values are statistically significant at $p < 0.05$. Statistical significance was compared within the groups as follows: *compared with control, $^{@}$ compared with diabetic rats.

CONCLUSION: The results of the present study clearly indicate that the *Hemidesmus indicus* root extract possess antihyperglycemic property evidenced from improved OGTT and muscle glycogen content. The significant improvement in the plasma lipid profile revealed the antidyslipidemic activity of the root extract. In addition, oral administration of *Hemidesmus indicus* roots extract protects the pancreas from oxidative damage which may be due to the attenuation of hyperglycemia and its mediated oxidative stress. The phytochemicals present in the root extract may account for these pharmacological actions. The results of the present study also provide a scientific rationale for the use of *Hemidesmus indicus* roots in the traditional medicine system.

REFERENCES:

1. American Diabetes Association: Diagnosis and classification of diabetes mellitus. Diabetes Care 2011; 34:S62-69.
2. Dey L, Attele AS, Yuan CS: Alternative therapies for type 2 diabetes. Alternative Medicine Review 2002; 7:45-58.
3. Austin A: A Review on Indian Sarsaparilla, *Hemidesmus indicus* (L.) R. Br. Journal of Biological Sciences 2008; 8:1-12.
4. Mors WB: Plants active against snake bite. Academic press, New York PA, 1991: 353-373.
5. Harborne JB: Phytochemical methods. Chapman and Hall Int., New York, Third Edition 1998.
6. Kokate CK: Pharmacognosy. Nirali Prakasham, Mumbai, India, Sixteenth Edition 2001.
7. Trinder P: Determination of glucose in blood using glucose oxidase with an alternate oxygen acceptor. Annals of Clinical Biochemistry 1969; 6:24-27.
8. Nayak SS, Pattabiraman TN: A new colorimetric method for the estimation of glycosylated haemoglobin. Clinica Chimica Acta. 1981; 109:267-274.
9. Omaye ST, Turnbull JD, Sauberlich HE: Selected methods for the determination of ascorbic acid in animal cells, tissues and fluids. Methods in Enzymology 1979; 62:3-11.
10. Desai ID: Vitamin E analysis methods for animal tissues. Methods in Enzymology 1984; 105:138-147.
11. Sedlak J, Lindsay RH: Estimation of total, protein bound and non-protein sulfhydral groups in tissue with Ellman's reagent. Analytical Biochemistry 1968; 25:293-305.
12. Okhawa H, Ohishi N, Yagi K: Assay for lipid peroxides in animal tissues by thiobarbituric acid reaction. Analytical Biochemistry 1979; 95:351-358.
13. Misra HP, Fridovich I: The role of superoxide anion in the auto-oxidation of epinephrine and a simple assay for superoxide dismutase. The Journal of Biological Chemistry 1972; 47:3170-3175.
14. Takahara S, Hamilton HB, Neel JV, Kobara TY, Ogura Y, Nishimura ET: Hypocatalasemia: a new genetic carrier state. The Journal of Clinical Investigation 1960; 39:610-619.
15. Rotruck JT, Pope AL, Ganther HE, Swanson AB, Hafeman DG, Hoekstra WG: Selenium: biochemical role as a component of glutathione peroxidise. Science 1973; 179:588-590.
16. Morales MA, Jabbagy AJ, Terenizi HR: Mutations affecting accumulation of Neurospora glycogen. News letter 1973; 20:24-25.
17. Parekh AC, Jung DH: Cholesterol determination with Ferric acetate, Uranylacetate and sulphuric acid-Ferrous sulphate reagents. Analytical Chemistry 1970; 42:1423-1427.
18. Rice EW: Triglycerides in serum. Academic Press, Newyork, 1970: 215.
19. Burstein M, Scholnick HR: Precipitation of chylomicron and very low density lipoprotein from human serum with sodium lauryl sulphate. Life Science 1972; 11:177-184.
20. Szkudelski T: The mechanism of alloxan and streptozotocin action in β cells of the rat pancreas. Physiological Research 2001; 50:537-546.
21. Jackson RL, Hess RL, and England JD: Haemoglobin A_1c values in children with over diabetes maintained in varying degree of correct. Diabetes care 1997; 2:391-395.
22. Freeman BA, Crapo JD: Biology of diseases: free radicals and tissue injury. Laboratory Investigation 1982; 47:412-426.
23. Manonmani G, Shavapriya V, Kalpana S, Govindasamy S, Apparanantham T: Antioxidant activity of Cassia fistula (Linn.) flowers in alloxan induced diabetic rats. Journal of Ethnopharmacology 2005; 97:39 - 42.
24. Sozmen EY, Sozmen B, Delen Y, Onat T: Catalase/superoxide dismutase (SOD) and catalase/paraoxonase (PON) ratios may implicate poor glycemic control. Archives of Medical Research 2001; 32:283-287.
25. Punitha ISR, Rajendran K, Shirwaikar A, Shirwaikar A: Alcoholic stem extract of Coscinium fenestratum regulates carbohydrate metabolism and improves antioxidant status in streptozotocin–nicotinamide induced diabetic rats. Evidence-based Complementary and Alternative Medicine: eCAM 2005; 2:375-381.
26. Hodgson EK, Fridovich I: The interaction of bovine erythrocyte superoxide dismutase with hydrogen peroxide: inactivation of the enzyme. Biochemistry 1975; 14:5294-5299.
27. Kojo S: Vitamin C: basic metabolism and its function as an index of oxidative stress. Current Medicinal Chemistry 2004; 11:1041–1064.
28. Naziroglu M, Butterworth P: Protective effects of moderate exercise with dietary vitamin C and E on blood antioxidative defense mechanism in rats with streptozotocin-induced

diabetes. Canadian Journal of Applied Physiology 2005; 30:172–185.
29. Ravikumar P, Anuradha CV: Effect of fenugreek seeds on blood lipid peroxidation and antioxidants in diabetic rats. Phytotherapy Research: PTR 1999; 13:197-201.
30. Stahl W, Sies H: Antioxidant defense. Vitamin E and carotenoids. Diabetes 1997; 46:14-18.
31. Garg MC, Ojha S, Bansal DD: Antioxidant status of streptozotocin diabetic rats. Indian Journal of Experimental Biology 1996; 34:264-266.
32. Anuradha CV, Selvam R: Effect of oral methionine on tissue lipid peroxidation and antioxidants in alloxan induced diabetic rats. The Journal of Nutritional Biochemistry 1993; 4:212-215.
33. Maritim AC, Sanders RA, and Watkins JB: Diabetes, oxidative stress, and antioxidants: A review. J Biochemical and Molecular Toxicology 2003; 17:24-38.
34. Arulselvan P, Subramanian SP: Beneficial effects of Murraya koenigii leaves on antioxidant defense system and ultrastructural changes of pancreatic ß-cells in experimental diabetes in rats. Chemico Biological Interactions 2007; 165:155-164.
35. Lenzen S: Oxidative stress: The vulnerable beta-cell. Biochemical Society Transactions 2008; 36:343-347.
36. Betteridge J: Lipid disorders in diabetes mellitus. Blackwell Science, London, Edition 2, 1997: 55.1–55.31.
37. Al-Shamaony L, Al-Khayraji SM, Twaiji IA. Hypoglycemic effect of Artemisia herba alba II: Effect of a valuable extract on some blood parameters in diabetic animals. Journal of Ethnopharmacology 1994; 43:167-171.
38. Rajalingam R, Srinivasan N, Govindarajulu P: Effect of alloxan-induced diabetes on lipid profiles in renal cortex and medulla of mature albino rats. Indian Journal of Experimental Biology 1993; 31:577–579.
39. Bopanna KN, Bhagyalakshmi N, Rathod SP, Balaraman R, Kannan J: "Cell culture derived Hemidesmus indicus in the prevention of hypercholesterolemia in normal and hyperlipidemic rats." Indian Journal of Pharmacology 1997; 29:105–109.
40. Khan A, Safdar M, Ali khan MM: Effect of various doses of cinnamon on lipidprofile in diabetic individuals. Pakistan Journal of nutrition 2003; 2:313-319.

****