ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 3, Issue, 5, pp.004-008, May, 2011

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

EVALUATION OF ANTI HYPERGLYCEMIC AND ANTI LIPID PEROXIDATIVE EFFECT OF *Costus igneus* NAK IN STREPTOZOTOCIN INDUCED DIABETIC RATS

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ARTICLE INFO

Article History:
Received 19th February, 2011
Received in revised form
11th March, 2011
Accepted 17th April, 2011
Published online 14th May 2011

Key Words:
Aldolase,
Antihyperglycemic,
Costus igneus.
Nak, Fiery costus,
Glucose-6- phosphate dehydrogenase,
Hypolipidemic.

ABSTRACT

Medicinal plants have been reported to play an important role in modulating glycemic responses and has preventive and therapeutic implications for certain conditions such as diabetes, hyperlipedemia etc. *Costus igneus*. Nak known to possess hypoglycemic effect was supplemented to streptozotocin induced diabetic rats and compared with that of conventional hypoglycemic agents (Insulin and Glibenclamide). *Costus igneus* powder at a level of 500mg/kg body weight, reduced blood glucose in the animals by 37% after 45 days of supplementation. Oral administration of *Costus igneus* powder significantly reversed the activity of the enzymes glucose - 6- phosphate dehydrogenase (G-6-P DH) and aldolase in the liver of experimental groups. The activity of aldolase in the liver of *Costus igneus* powder and Insulin treated groups was 0.19u/g and in Glibenclamide treated group the activity was 0.18u/g protein. The activities of AsAT and AlAT decreased significantly in animals treated with *Costus*, Insulin and glibenclimide. It was also observed that total cholesterol and triglyceride levels were significantly low in *Costus igneus* treated group compared to other groups. The results prove that *Costus* could effectively reduce the blood glucose, total cholesterol, triglycerides and also reverse the activity of elevated enzymes which can prove beneficial in the management of hyperglycemia.

INTRODUCTION

Diabetes mellitus is a complex disorder that is characterized by hyperglycemia resulting from malfunction in insulin secretion and/or insulin action both causing impaired metabolism of glucose, lipids and protein (Kim *et al.,* 2006). The pathogenesis of diabetes mellitus is managed by glycemic control, exercise, insulin, oral administration of hypoglycemic drugs such as sulfonylureas and biguanides and use of lipid lowering drugs (Akhtar *et al.,* 2007). Despite the presence of known antidiabetic medicine in the pharmaceutical market, diabetes and the related complications continue to be a major medical problem (Kim *et al.,* 2006). Traditional medicinal plants have been used since ancient times to treat a great variety of human diseases such as diabetes, coronary heart disease and cancer (Tiwari and Rao, 2002; William, Lakshminarayanan and Chegu, 1993). Clinical examinations have demonstrated hypoglycemic and hypolipidemic activity in extracts from many plants (Kelkar *et al.,* 1996; Ragavan and Krishnakumari, 2006; Ragavan and Krishnakumari, 2006; Kumar Shetty and Salimath 2005; Vasanthamani and Savitha, 2001; Chandrashekar, Mukherjee and Mukherjee, 1989; Kaleem *et al.,* 2006). Hypercholesterolemia and hypertriglyceridemia are common complications of diabetes mellitus in addition to hyperglycemia.

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The frequency of hyperlipidemia in diabetes is indeed very high, depending on the type of diabetes and its degree of control (Akhtar *et al.,* 2007). Several studies have reported increases in the concentration of lipid peroxides in the blood and urine of diabetics, and also considerable changes in the structural organization and functions of red blood cell membrane are seen (Shukla *et al.,* 2000). Medicinal plants have an important role in modulating glycemic responses and have preventive and therapeutic implications for certain conditions such as diabetes, hyperlipedemia etc Many Indian medicinal plants have been found to be useful in successfully managing diabetes, significant among them are *Gymnema Sylvestre, Pterocarus Marupium, Eugenia Jambolana, Swertia Chiraita, Syzigium Cumini, Momordica Charantia, Fenugreek, T. arjuna,* the active principles have been isolated from some of them (Kaleem *et al.,* 2006, Shukla *et al.,* 2000). The extracts of *Morus indica* L, have been reported to possess medicinal properties including hypoglycemic, hypotensive and diuretic activities (Andallu *et al.,* 2001). *Costus igneus* Nak commonly known as insulin plant or Fiery costus belongs to the family Costeceae is found in tropical Africa, Australia, Asia and north, central and south America. It is known to posses hypoglycemic activity, it has been reported that people eat one leaf a day to keep their blood glucose levels low. Previous studies in our laboratory have established antihyperglycemic and antioxidant effects of *Costus igneus in vitro* and *ex vivo* techniques. Also there is no scientific

documentation regarding the blood glucose lowering effect of *Costus igneus in vivo*. With this background the present study was planned to evaluate the effect of *Costus igneus* on blood glucose, on lipid profile and on the enzymes of carbohydrate and compare with the treatment of conventional drugs (Insulin and Glibenclamide).

MATERIALS AND METHODS

Fresh *Costus igneus*. Nak leaves (Insulin plant, CIP) were obtained from a Horticulture farm, Mysore, India, the plant material was identified by a botanist at the department of Botany, University of Mysore, Mysore, India. The leaves were washed, oven dried (55-60°C), ground, passed through sieve and stored in airtight container at refrigeration temperature before use. Streptozotocin was procured from Sigma chemicals, Bangalore. GOD-POD kit from Span Diagnostics (Surat, India). Glucose-6-phosphate dehydrogenase (G-6-P) and Aldolase kits from Randox Laboratories Ltd. Worli, Mumbai. Glutamic oxaloacetic transaminase (AsAT) and Glutamic pyruvate transaminase (AlAT) kits from Aggappe Diagnostics Ltd, Kerala. Total cholesterol, Triglycerides kits from Coral clinical systems, Verna, Goa. Tris (hydroxymethyl) aminomethane from SD Fine Chemicals, Bombay. All the other chemicals used were of analytical grade and purchased locally. Male albino rats (30) of Wister strain with body weights ranging from 150-200g were procured from central animal house Department of Zoology, University of Mysore. Permission was taken from the Animal Ethical Committee of the University for using animals for the study. The animals were housed in individual cages and were allowed to acclimatize with cereal-pulse based diet which consisted of wheat flour (62%), defatted Soya flour (18%), groundnut oil (10%), sugar (7%), vitamin mix (1%) and mineral mix (2%) and water was provided adlibitum.

Experimental design

The animals were divided into five groups (n=6) based on their weights using Randomized block design, as follows: Group I – Normal control (NC), Group II - Diabetic control (DC), Group III - Diabetic group treated with *Costus* powder (CIP), Group IV - Diabetic group treated with Insulin (INS), Group V - Diabetic group treated with Glibenclamide (GB).
Animals of group II, III, IV and V were rendered diabetic by a single i.p injection of Streptozotocin (STZ) (55mg/kg b.wt) (Andallu, and Varadacharyulu, 2003) prepared in freshly prepared 0.1M citrate buffer after an overnight fast. The diabetic animals were provided 5% glucose solution for 24 h following Streptozotocin injection to prevent initial drug-induced hypoglycemic mortality. After 72 h of injection, blood was drawn from Retro Orbital Plexus (RPO) of anaesthetized animal which were fasted overnight to check the fasting blood glucose. Rats with fasting blood glucose more than 250mg/dl were selected for the experimental group.

Powder of *Costus igneus*. Nak at a level of 500mg/kg body weight was mixed with the diet and provided to the animals of CIP Group. Animals of INS group were injected with insulin daily (5 units/kg body weight), whereas, Glibenclamide was dissolved in distilled water and fed orally (400µg/kg body weight) daily to the animals of GB group (Sheela and Augusti, 1992). The animals were maintained with above treatment for a period of 45 days. The weights of the animals were monitored weekly. During the study period, daily food and water consumption was determined and expressed as intake/week ± SD.

Blood collection

At the end of the study period, the animals were fasted for 12hr, anaesthetized (diethyl ether) and dissected, cardiac blood was collected immediately into test tube and allowed to clot for 30min at 2˚C. The tubes were then centrifuged at 2500rpm for 20min in cold condition (4˚C). The serum was aspirated into ependoff tubes and used for biochemical estimations. The liver was excised, washed with saline and weighed, phosphate buffered saline (pH 7.4) was added to liver 1:5 (w/v), and homogenized using Teflon pestle. The homogenate was centrifuged at 2500rpm (5min); the supernatant was used for the estimation of biochemical parameters.

BIOCHEMICAL PARAMETERS

Blood glucose: Blood from tail vein of the overnight fasted rats was drawn weekly and blood glucose was estimated immediately by Glucose-Oxidase Peroxidase kit (Span- India) in protein free supernatant. The threshold of urine sugar of the overnight fasted animals was determined weekly using Uristix.

Estimation of G-6-P DH and Aldolase activity: G-6-P DH and Aldolase in the liver homogenate was estimated using standard diagnostic kits (Randox).

Estimation of Lipid peroxides: Lipid peroxides in the serum and liver homogenate were measured according to the method of Ojhawa, Ohishi and Yagi, (1979). The lipid peroxidation products react with thiobarbituric acid forming a pink coloured adduct on boiling which was measured.

Estimation of reduced Glutathione: Reduced glutathione (GSH) in the serum and liver homogenate was estimated based on the reaction of 5,5'dithiobis-2-nitrobenzoic acid (DTNB) with compounds containing sulphydryl groups (Beutler, Duron and Kelly, 1963).

Estimation of AsAT, AlAT, Triglycerides and total cholesterol: AsAT, AlAT, Triglycerides and total cholesterol in the serum were estimated at the end of the study period using standard kits (Agappe).

Statistical analysis: Data were recorded as means ± standard deviation of duplicate measurements and subjected to one way ANOVA using SPSS software.

RESULTS

The effect of *Costus igneus* on fasting blood glucose, carbohydrate metabolizing enzymes (glucose-6-phosphate dehydrogenase and aldolase), Total cholesterol and Triglycerides were studied in control and streptozotocin induced diabetic rats. The body weights of the diabetic control group decreased significantly ($p<0.05$) during the study period (Table 1). There was reduction in the body weights of the animals treated with CIP, INS and GB at the end of first week. However the body weights of the animals increased gradually

Table 1.Changes in body weights, Food and water consumption patterns of rats treated with *Costus igneus*

Rat group	Body weight(g)				Food intake (g)				Water intake (ml)			
	Initial	2nd wk	4th wk	6th wk	1st wk	2nd wk	4th wk	6th wk	1st wk	2nd wk	4th wk	6th wk
NC	144 ± 17.2	184 ± 9.9	209 ± 7.7	231 ± 9.3	67.8 ± 7.7	68.7 ± 3.7	112.6 ± 4.3	138 ± 9.9	57.2 ± 6.1	72.5 ± 2.8	98.8 ± 5.4	118 ± 8.0
DC	192^{a} ± 7.5	181^{a} ± 6.5	161^{a} ± 7.3	152^{a} ± 5.5	88.8^{a} ± 6.5	101.0^{a} ± 7.5	136.4^{a} ± 8.2	177^{a} ± 6.5	93.4^{a} ± 7.2	104.2^{a} ± 8.3	145.6^{a} ± 7.5	168^{a} ± 5.8
CIP	159^{b} ± 17.3	142^{b} ± 21.9^{b}	139^{b} ± 8.1	160^{b} ± 8.5	55.6^{b} ± 2.5	64.4^{b} ± 9.7	128.9^{b} ± 10.5	158^{b} ± 13.9	42.9^{b} ± 2.5	81.8^{b} ± 9.7	136.5^{b} ± 8.4	161^{b} ± 10.8
INS	155^{b} ± 17.9	179^{c} ± 21.7	198^{c} ± 21.7	224^{c} ± 17.0	47.8^{c} ± 3.8	73.4^{c} ± 4.5	118.4^{c} ± 6.2	151^{c} ± 11.2	40.4^{c} ± 4.1	75.3^{c} ± 3.6	120.6^{c} ± 5.8	148^{c} ± 10.4
GB	157^{b} ± 26.0	168^{d} ± 35.8	180^{d} ± 37.3	204^{d} ± 37.2	51.5^{d} ± 3.1	80.2^{d} ± 11.0	126.2^{d} ± 3.5	162^{d} ± 5.8	43.5^{d} ± 3.4	83.0^{d} ± 8.6	131.4^{d} ± 4.5	158^{d} ± 4.7

Mean values carrying superscripts a, b, c and d in columns differ significantly ($p<0.05$).
NC- Normal Control, DC- Diabetic control, CIP – *Costus igneus* leaves powder, INS – Insulin, GB – Glybenclamide.

Table 2. Blood glucose, glucose-6-phosphate dehydrogenase and aldolase levels of the animals

Rat group	Blood glucose (mg/dl)				Enzymes (liver)	
	Initial	2nd wk	4th wk	6th wk	G-6-P DH (mu/mg P)	Aldolase (u/g P)
NC	81 ± 11.3^{a} (1± 0.0)	79 ± 5.24^{b} (1 ± 0.0)	80 ± 7.03^{c} (1 ± 0.0)	82 ± 3.61^{d} (1 ± 0.0)	1.16 ± 0.28	0.16 ± 0.03
DC	286 ± 25.0^{al} (4 ± 0.001)	460 ± 63.7^{bl} (4 ± 0.001)	473 ± 26.8^{cl} (4 ± 0.001)	481 ± 25.11^{dl} (4 ± 0.001)	0.54 ± 0.04^{a}	0.24 ± 0.03^{a}
CIP	335 ± 69.65^{am} (2.8 ± 0.8)	287 ± 49.43^{bm} (1.5 ± 1.2)	260 ± 39.01^{cm} (1.6 ± 0.82)	210 ± 52.06^{dm} (1.6 ± 0.82)	0.92 ± 0.48^{b}	0.19 ± 0.07^{b}
INS	345 ± 57.44^{an} (4 ± 0.001)	109 ± 6.29^{bn} (1 ± 0.00)	101 ± 2.08^{cn} (1 ± 0.0)	101 ± 1.91^{cn} (1 ± 0.0)	0.98 ± 0.10^{d}	0.19 ± 0.02^{b}
GB	364 ± 34.52^{ao} (4 ± 0.001)	149 ± 9.95^{bo} (1 ± 0.00)	142 ± 5.75^{co} (1 ± 0.0)	123 ± 19.54^{do} (1 ± 0.0)	1.04 ± 0.42^{c}	0.18 ± 0.05^{c}

NC- Normal Control, DC- Diabetic control, CIP – *Costus igneus* leaves powder, INS – Insulin, GB – Glibenclamide. n= 6 in each group.
Mean values carrying superscripts a, b, c and d in rows and l, m, n and o in columns differ significantly ($p<0.05$). Values in parenthesis represent % urine sugar. 1- Nil, 2- Traces, 3- 1%, 4- >2%.

Table 3. Lipid peroxides, Glutathione, AsAT, AlAT, Urea and Creatinine levels of the animals

Animal group	Liver homogenate		Serum					
	MDA (nm/mg P)	GSH (µm/mg P)	MDA (nm/mg)	GSH (µm/mg P)	AsAT (u/ml)	AlAT (u/ml)	Urea (mg/dl)	Creatinine (mg/dl)
NC	0.05 ± 0.01	1.28 ± 0.26	0.08 ± 0.01	0.27 ± 0.26	53.3 ± 2.3	42.3 ± 1.51	23.03 ± 1.47	0.80 ± 0.07
DC	0.43 ± 0.03^{a}	0.55 ± 0.10^{a}	0.29 ± 0.03^{a}	0.05 ± 0.01^{a}	256.6 ± 70.9^{a}	65.4 ± 19.1^{a}	68.94 ± 7.03^{a}	1.26 ± 0.17^{a}
CIP	0.18 ± 0.07^{b}	3.41 ± 0.76^{b}	0.22 ± 0.06^{b}	0.11 ± 0.05^{b}	119.2 ± 49.3^{b}	53.3 ± 17.7^{b}	36.90 ± 27.41^{b}	0.96 ± 0.25^{b}
INS	0.16 ± 0.01^{b}	3.91 ± 0.10^{c}	0.15 ± 0.02^{c}	0.17 ± 0.03^{c}	96.3 ± 21.4^{c}	47.6 ± 14.3^{c}	42.58 ± 15.3^{c}	0.84 ± 0.48^{c}
GB	0.21 ± 0.04^{c}	1.07 ± 0.39^{d}	$0.21 0 \pm .06^{b}$	0.17 ± 0.03^{c}	102.5 ± 28.3^{d}	52.8 ± 9.2^{b}	36.28 ± 7.27^{b}	1.04 ± 0.35^{d}

NC- Normal Control, DC- Diabetic control, CIP – *Costus igneus* leaves powder, INS – Insulin, GB – Glibenclamide. n= 6 in each group. Mean values carrying superscripts a, b, c and d in columns differ significantly ($p<0.05$).

during the study period. The average weekly food intake was significantly ($p<0.05$) low in the experimental groups (CIP- 55.5g, INS - 47.8 g and GB - 51.5g) compared to the healthy control group (67.8g), whereas the food intake of untreated diabetic group (88.8g) was higher compared to control group during the first week of induction of diabetes (Table 1). Food intake of the experimental group increased from second week of the study period. The average weekly water intake of the uncontrolled diabetic group was significantly high compared to other groups and same pattern was observed throughout the study.

Supplementation of *Costus igneus* powder for 45 days resulted in a consistent and gradual decrease in blood glucose levels which was significantly ($p< 0.05$) low compared to DC (Table 2). Fasting blood glucose levels decreased from an initial level of 335 ± 69.65 to 210 ± 52.8 mg/dl in the diabetic group treated with CIP. As expected, normoglycemia was attained in INS and GB treated groups. A significant ($p<0.05$) decrease in the urine sugar was observed in all the experimental groups compared to DC. Aldolase activity in the liver significantly ($p<0.05$) increased in diabetic rats, compared to healthy control. Supplementation of

Costus igneus powder for 45 days significantly reversed the activity which was almost comparable to that of control group. Aldolase activity in the liver of CIP group was comparable to that of INS group (19u/g protein). The activity of G-6-P DH decreased significantly ($p<0.05$) in untreated diabetic group (0.54 ± 0.04). Treatment with CIP, INS and GB resulted in an increase in G-6-P DH activity (0.92 ± 0.48, 0.98 ± 0.10 and 1.04 ± 0.42mu/mg protein). Serum cholesterol (TC) and triglyceride (TG) levels in all five groups of animals are shown in Figures 1 and 2 respectively. The serum TC and TG levels were significantly higher in diabetic rats

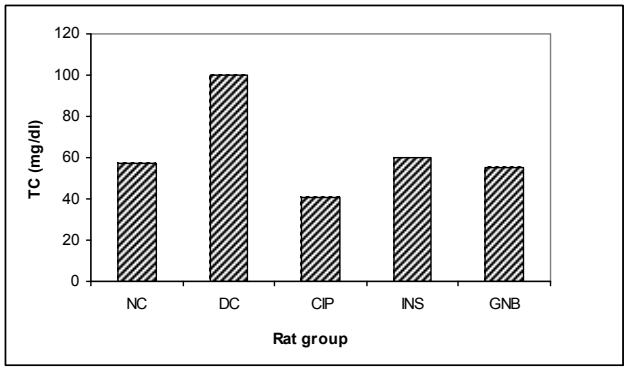

Fig. 1. Total cholesterol levels of the animals
NC- Normal Control , DC- Diabetic control, CIP – *Costus igneus* leaves powder, INS – Insulin, GB – Glibenclamide

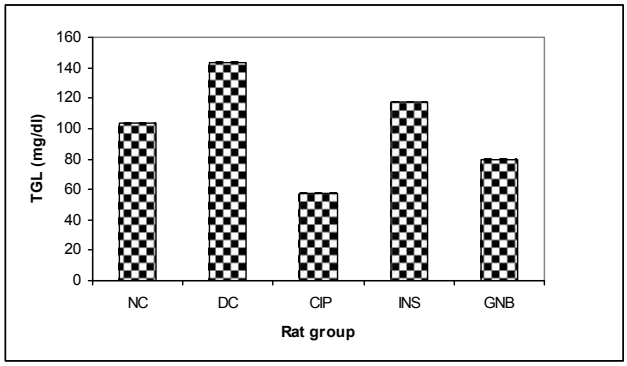

Fig. 2. Tryglyceride levels of the animals
NC- Normal Control, DC- Diabetic control, CIP – *Costus igneus* leaves powder, INS – Insulin, GB – Glibenclamide

compared to those in normal rats. Treatment with CIP caused a significant reduction ($p<0.05$) in both TC and TGL compared to INS and GB group. It was observed that the lipid peroxides both in the liver homogenate and in the serum of CIP were significantly low compared to DC and GB (Table-3), the peroxide content in the liver of the CIP group was 0.18 ± 0.07 Nm/mg P, whereas it was 0.21 ± 0.04 and 0.43 ± 0.03 Nm/mg P in GB and DC group respectively. MDA in serum of the CIP was 0.22 ± 0.06 nm/mg P which was significantly low compared to DC (0.29 ± 0.03 Nm/mg P) and GB (0.21 ± 0.06 Nm/mg P). However, MDA in liver and in the serum were significantly low in INS group compared to all the experimental groups. Supplementation of *Costus igneus* significantly increased the activity of GSH (3.41 ± 0.76 µm/mg P) which was comparable to INS group (3.91 ± 0.10 µm/mg P). Serum GSH in CIP group was significantly low (0.11 ± 0.05 µm/mg P) compared to INS (0.17 ± 0.03 µm/mg P) and GB (0.17 ± 0.03 µm/mg P). Induction of diabetes elevated the activity of AsAT and AlAT in the animals, treatment with *Costus* significantly ($p<0.05$) decreased the activity of AsAT and AlAT to 119.2 ± 49.3 and 53.3 ± 17.7u/ml respectively and was comparable to that of GB group.

DISCUSSION

In the present study increased food and water consumption was observed in the experimental groups in comparison to normal rats indicating polydypsia and loss of body weight due to excessive breakdown of tissue proteins (Kameswararao, Kesavulu and Apparao, 2003). It has been reported that *M. indica* powder decreased the food intake and there was a gradual increase in the body weights of the animals compared to control diabetic group (Andallu and Varadacharyulu., 2003). Increase in the body weights in the experimental groups may probably be due to the improvement in insulin secretion and Glycemic control. Similar observation have been reported in the diabetic animals treated with *Ficus bengalensis* and *Trigonella foenum greacum* (Kameswararao, Kesavulu and Apparao, 2003). The average weekly water intake was significantly higher in all the experimental groups compared to control groups throughout the study. Data on blood glucose of the present study indicates that CIP is effective in lowering the blood glucose indicating the antihyperglycemic effect of *Costus igneus.*

Liver acts as a "glucostat" and plays a vital role in the maintenance of blood glucose level and hence it was of interest to examine the possible role of *Costus igneus* on enzymes of carbohydrate metabolism in liver. Aldolase, one of the key enzymes in the glycolytic pathway, increases in diabetes and this may be due to cell impairment and necrosis (Ragavan and Krishnakumari, 2006). The higher activity of Glucose-6-phosphate dehydrogenase in the liver of CIP group compared to untreated diabetic group suggests the utilization of glucose by citric acid cycle and the pentose pathway (Khan, Abraham and Leelamma, 1995). The reduction in the blood glucose of the experimental groups may be due to higher rate of glycolysis as evidenced by the activity of aldolase and Glucose-6-phosphate dehydrogenase, two of the key enzymes of Glycolysis (Ragavan and Krishnakumari, 2006). The activities of AsAT and AlAT in the circulation are measured as the indicators of hepatic damage (Kim *et al.,* 2006).

The concurrent effect of *Costus igneus* therapy on fatty acid metabolism was significant in diabetic animals, this was evidenced by the reduction of serum cholesterol, triglycerides and lipid peroxides in animals treated with *Costus igneus*. Increased lipid peroxides in the blood and in the urine have been reported in diabetics and it is also evidenced that glucose undergoes metal catalyzed auto-oxidation leading to the production of hydroxyl radicals which are known to attack polyunsaturated fatty acids in bio membranes inducing increased lipid peroxidation Shukla et.al., 2000). In this study, it is evident that *Costus igneus* treatment decreases lipid peroxidation in blood and liver homogenate due to its hypoglycemic nature.

Conclusion

The results suggest that treatment with *Costus* could be beneficial in hyperglycemia and hyperlipemia associated with diabetes mellitus. Further studies are needed to evaluate the actual therapeutic value of this medicinal plant.

REFERENCES

Akhtar, M. A., Rashid, M., Wahed, M. I. I., Islam. M. R, Shaheen, S. M., Islam, M. A., Amran, M. S. and Ahmed, M., 2007. Comparison of long-term Antihyperglycemic and hypolipidemic effects between *Coccinia cardifolia* (Linn) and *Catharanthus roseus* (Linn.) in alloxan-

induced diabetic rats. *Res. J. Medcine, Medical Sci.,* 2(1), 29-34.

Andallu, B., Suryakantham, V. V., Srikanthi, B. L. and Reddy, G. K., 2001. Effect of mulberry (*Morus Indica.* L*)* therapy on plasma and erythrocyte membrane lipids in patients with type-2 diabetes. *Clin. Chem Acta.,* 314, 47-53.

Andallu, B. and Varadacharyulu, N. C., 2003. Antioxidant role of mulberry (*Morus Indica.* L.Cv. Anantha) leaves in streptozotocin-diabetic rats. *Clin. Chem. Acta.,* 338, 3-10.

Chandrashekar, B., Mukherjee, B. and Mukherjee, S. K., 1989. Blood sugar lowering potentiality of selected Cucurbitaceae plants of Indian origin. *Ind. J. Med. Res,* 300-305.

Beutler, E., Duron, O. and Kelly, B. M., 1963. Improved method for the determination of blood Glutathione. (pp. 882-90) J. Lab Clin Med 61.

Kameswararao, B., Kesavulu, M. M. and Apparao, C., 2003. Evaluation of antidiabetic effect of Momordica cymbalaria fruit in alloxan-diabetic rats. *Fitoterapia*, 74, 7-13.

Kaleem, M., Kirmani, D., Asif, M., Ahmed, Q. and Bano, B., 2006. Biochemical effects of Nigella Sativa L seeds in diabetic rats. *Ind. J. Exptl Biol.,* 44, 745-748.

Kelkar, S. M., Bapat, V. A., Ganapathi, T. R., Kaklij, G. S., Rao, P. S. and Heble, M. R., 1996. Determinations of hypoglycemic activity in *Morus indica* L. (Mulberry) shoot cultures. *Curr Sci.,*1-72.

Khan, B. A., Abraham. A. and Leelamma., 1995. Hypoglycemic action of *Murraya koenigii* (curry leaf) and *Brassica juncea* (mustard): Mechanism of action. Ind. *J Biochem, Biophys,* 32, 106-108.

Kim, J. S., Ju, J. B., Choi, C. W. and Kim, S. C., 2006. Hypoglycemic and Antihyperlipidemic Effect of Four Korean Medicinal Plants in Alloxan Induced Diabetic Rats. *Am. J. Biochem Biotech,* 2 (4), 154-160.

Kumar, G. S., Shetty, A. K. and Salimath, P. V., 2005. Modulatory effect of fenugreek seed mucilage and Spent Turmeric on intestinal and renal disaccharidases in streptozotocin induced diabetic rats. *Plant and Human Nutrn*, 60, 87-91.

Ojhawa, H., Ohishi, N. and Yagi, K., 1979. Assay for lipid peroxides in animal's tissue by Thiobarbituric reaction. *Anal. Biochem,* 95, 351-358.

Ragavan, B. and Krishnakumari., S., 2006. Antidiabetic effect of T. Arjuna bark extract in alloxan induced diabetic rats. *Ind. J. Clin. Biochem,* 21(2), 123-128.

Sheela, C. G. and Augusti, K. T., 1992. Antidiabetic effects of S-allyl cysteine sulphoxide isolated from garlic Alliumsativum Linn. *Ind. J.Exptl Biol.,* 30*,* 1491.

Shukla, R., Sharma, S. B., Puri, D., Prabhu, K. M. and Murthy, P. S., 2000. Medicinal plants for treatment of diabetes mellitus. *Ind. J. Clin. Biochem,* 15, 19.

Tiwari, A. K. and Rao, J. M., 2002. Diabetes mellitus and multiple therapeutic approaches of phytochemicals: Present status and future prospects. *Curr. Sci.,* 23(1), 30-33.

Vasanthamani, G. and Savitha, D., 2001. Hypoglycemic and hypocholesterolemic effect of selected herbal powder. Indian. *J. Nutrn Dietetics,* 33, 419-427.

William, F., Lakshminarayanan, S. and Chegu, H., 1993. Effect of some Indian vegetables on glucose and insulin in diabetic subjects. *International J. Fd Sci Nutrn,* 44, 191-196.

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