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ANTIHYPERGLYCEMIC AND ANTIOXIDATIVE EFFECT OF HYDRO-METHANOLIC EXTRACT OF LEAF OF *ABROMA AUGUSTA* IN STREPTOZOTOCIN INDUCED DIABETIC MALE ALBINO RAT

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ABSTRACT: The present study was conducted to investigate protective effect of hydro-methanolic (2:3) extract of leaf of *Abroma augusta* in streptozotocin induced diabetic male albino rat. For this purpose animals were divided into three treatment groups (n = 6): control group, STZ induced diabetic group (STZ 4 mg / 0.1 ml citrate buffer/ 100 g body weight), hydro-methanolic extract of leaf of *Abroma augusta* treated group (20 mg / 0.5 ml distilled water/100 g body weight). Treatment was conducted for 28 days. Blood glucose, serum insulin, glycated haemoglobin levels along with activities of hepatic carbohydrate metabolic enzymes, hexokinase and glucose-6-phosphate dehydrogenase were assed in all experimental groups. Oxidative stress markers like catalase, peroxidase enzyme activities, conjugated diene and thiobarbituric acid reactive substance levels in liver were measured. All these parameters were significantly recovered towards the control level after the treatment of hydro-methanolic extract. Pancreatic islet diameter, count of islet and number of cells in islets also decreased in diabetic animals. Treatment of these animals with extract resulted significant recovery towards the control level. Serum glutamate oxaloacetate transaminase and glutamate pyruvate transaminase were assed in all the groups and it has been revealed that the said extract has no metabolic toxicity in general. From this study it may be concluded that hydro-methanolic extract of leaf of *A. augusta* has protective effects on diabetes induced complications.

INTRODUCTION: Diabetes mellitus (DM) is a group of metabolic syndrome [1] associated with both micro vascular and macro vascular diseases affecting several organs [2]. Many complications are occurred which results increase risk of premature death. In uncontrolled diabetes risk of fatal death is increased and it is about 43% of total world population [3]. About 366 million people are suffering from DM over the world and the incidence of this disease is predicted to be more than double by the year of 2030 [4].

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Chronic hyperglycemia produces oxidative stress that also associated with dysfunction and apoptosis of several organ and cell including pancreatic β-cells, neurons and glial cells [5, 6]. Many drugs are used for their anti-diabetic action [7] but the main disadvantage of currently available drugs is that they have to be given throughout the life and produce side effects [7]. Insulin is not also affordable in low income country [3] and long term use of insulin formed insulin resistance, anorexia nervosa, brain atrophy and fatty liver [8, 9].

Medicinal plants and their bioactive constituents can be used for the treatment of DM throughout the world especially in our country as these are less toxic. These medicinal plants interact directly with our body chemistry without any side effects. There is increasing demand by patients to use natural products having anti-diabetic activity [10].

Abroma augusta (*A. augusta*) (common name is ulatkambal in Hindi) is an evergreen shrub, found throughout the hot and humid parts of India. Different parts of this tree are used widely in ayurvedic drug preparation to cure different diseases such as uterine disorder, inflammation, rheumatic pain of joints, dysmenorrhea, gonorrhea, headaches and diabetes [11]. From folk medicine reputation it has been revealed that people use the leaf of this plant as antidiabetic medicine. Some preliminary work has been done for the protection of diabetic complications by methanolic extract of leaf of *A. augusta* [12]. By trial and error method we have selected hydro-methanolic extract for better efficacy as hydro-methanolic solution 40:60 (water / methanol) ratio is the most preferred procedure for extraction of all pharmacologically active substances present in raw plant material. All kinds of polar and non-polar molecules are extracted by this technique. This present study was conducted to search out the protective effect of hydro-methanolic extract of leaf of *A. augusta* in diabetes induced complications.

MATERIALS AND METHODS:

Materials:

Collection of Plant Materials: Fresh and matured leaves of *A. augusta* were collected from local area in the month of June and the material was authenticated by taxonomist of Botany Department, Vidyasagar University. Leaves are dry in shed at room temperature 25 ºC.

Animal Material:

Selection of Animal and Animal Care: Eighteen matured normoglycemic male albino rats, weight of 120 ± 10 were selected for this experiment and approved by institutional Animal ethical Commetee Reg no. 2013/GO/Re/S/18/CPCSEA, DOR-1/5/18. The rats were collected from Saha Enterprise, authorized dealer of CPCSEA registered under Ministry of Environment and Forest. Rats were divided into three cages and housed for 15 days in our laboratory at 25 ± 2 °C temperature with 12 h: 12 h light, dark cycle and proper humidity prior to the experiment for acclimatization. Rats were fed with normal pellet diet and water *ad libitum*.

Reagents: Streptozotocin was purchased from Alfa Aesar, United States. Insulin (ELISA) kit was purchased from Boehringer Mannheim Diagnostic, Mannheim, Germany. GOT, GPT and glycated haemoglobin kit was purchased from Span Diagnostic Limited, Surat, India.

Methods:

***A. augusta* Leaves Extract Preparation:** Fresh leaves of *A. augusta* washed in normal distilled water and cut into small pieces and leaves were dried in shed at room temperature 25 ºC then dried in an incubator for 2 days and crushed. 50 g of crushed leaves were dissolved in 1000 ml of hydro-methanol (40:60) respectively in glass jar in the airtight condition with occasional shaking. After 7 days filtrates are collected, dried by rotary evaporator and stored in refrigerator.

Induction of Diabetes: Rats were fasted for 12 h before induction of diabetes. After this period they were subjected to single intramuscular injection of streptozotocin (STZ) at the dose of 4 mg / 0.1 ml citrate buffer / 100 g body weight/rat.

Experimental Design: Eighteen rats were taken for this experiment and they were divided in three equal groups.

Group I (Normal Control): Rats were injected single intramuscular injection of citrate buffer at the dose of 0.1 ml / 100 g body weight/rat followed by oral administration of 0.5 ml distilled water / 100 g body weight/rat/day as vehicle for 28 days.

Group II (Diabetic Group): Rats were received single intramuscular injection of streptozotocin at the dose of 4 mg / 0.1 ml citrate buffer / 100 g body weight/rat followed by oral administration of 0.5 ml distilled water / 100 g body weight/rat for 28 days.

Group III (Hydro - Methanolic Extract Treated Group): Diabetic rats of this group were subjected to oral treatment of hydro-methanolic extract of leaf of *A. augusta* at the dose of 20 mg / 0.5 ml distilled water / 100 g body weight / rat for 28 days. On the 29th day of the experiment, final body weight was recorded and blood glucose level was measured by the single touch glucometer. After the completion of treatment schedule all the animals were sacrificed by using euthanasia. Euthanasia is defined as a painless or stress free death. The experimental animal were sacrificed by inhalation of gases *i.e*. carbon dioxide, carbon monoxide, carbon dioxide plus chloroform / halothane as a

euthenics agents. After sacrificed, blood was collected from portal vein for the assessment of blood glucose, serum insulin, glycated haemoglobin level along with serum GOT and GPT levels. Liver were dissected out and stored at -80 °C for biochemical analysis of carbohydrate metabolic enzyme like hexokinase, Glucose-6-phosphate dehydrogenase and oxidative stress measuring biosensors such as catalase, peroxidase, Conjugated Diene (CD) and Thiobarbituric acid reactive substance (TBARS). Pancreas was collected from each animal for histological study.

Testing of Fasting Blood Glucose Level: Fasting blood glucose (FBG) levels were measured in each group at the time of starting of the treatment and every 7 days interval by the single touch glucometer [13]. Blood was collected from the tip of the tail vain of all rats.

Serum Insulin Level: Enzyme Linked Immuno-sorbant Assay (ELISA) kit was used for the detection of serum insulin [14]. Serum insulin level was expressed in µIU/ml.

Glycated Haemoglobin: Glycated haemoglobin was measured using the whole blood by standard kit method [15].

Biochemical Assay of Hexokinase Activity in Liver: Liver hexokinase activity was measured on the basis of reduction of NADPH coupled with hexokinase at 340 nm by spectrophotometer [16]. Liver tissue was homogenized in 0.1 M ice cold phosphate buffer saline (pH 7.4) at the tissue concentration of 50 mg/ml.

Biochemical Assay of Glucose-6-Phosphate Dehydrogenase Activity in Liver: The glucose-6-phosphate dehydrogenase activity was measured by spectrophotometrically [17] at 340 nm. Enzyme activity was determined by the reduction of NADP / min.

Catalase and Peroxidase in Liver: Catalase activity was estimated by the standard method [18]. Tissue concentrations was 50 mg/ml. Enzyme activity expressed as mM H_2O_2 consumption/mg of tissue/min. Liver peroxidase activity was measured by the standard method [19].

CD and TBARS in Liver: Conjugated Diene (CD) [20] and thiobarbituric acid reactive substance (TBARS) [21] levels in hepatic tissue were measured by the standard method. Tissue concentration was 50 mg / ml in phosphate buffer saline.

SGOT and SGPT: Serum GOT and GPT activities were assessed by standard kits [22] following manufacturer protocol for assessment.

Histology of Pancreas: Pancreas was fixed in bouin's solution and paraffin sections were prepared according to standard protocol. Pancreas sections were stained by haematoxylin and eosin by the standard method [23]. Pictures were taken at 400X magnification.

Statistical Analysis: ANOVA followed by multiple comparison two tail't'-test was performed for statistical analysis of collected data by the use of SPSS16 software [24].

RESULTS:

Body Weight: Final body weight of the diabetic group was significantly decreased in compare to the control group. There was significant recovery of this parameter was noted to the control level after the treatment of hydro-methanolic extract of leaf of *A. augusta* to the diabetic rat **Table 1**.

TABLE 1: CHANGES IN BODY WEIGHT ON HYDRO-METHANOLIC EXTRACT OF LEAF OF *A. AUGUSTA* TREATED DIABETIC RATS

	Body weight (gm)	
	Before treatment	**After treatment**
Control	128.75 ± 1.89^a	141.13 ± 0.92^a
Diabetic	126.92 ± 1.44^a	88.67 ± 2.43^b
Hydro methanolic extract treated group	127.17 ± 2.97^a	136.54 ± 1.37^a

Data are expressed as Mean ± SE, n = 6. Different superscripts (a, b) in each vertical column significantly differ from in each other ($p < 0.05$).

TABLE 2: EFFECT OF HYDRO-METHANOLIC EXTRACT OF LEAF OF *A. AUGUSTA* ON BLOOD GLUCOSE LEVEL IN STREPTOZOTOCIN INDUCED RATS

	Blood glucose (mg/dl)				
	1st Day	**7th Day**	**14th Day**	**21th Day**	**28th Day**
Control	81.43 $\pm 1.7^a$	80.32 $\pm 1.9^a$	82.07 $\pm 1.8^a$	83.44 $\pm 2.0^a$	85.77 $\pm 1.9^a$
Diabetic	318.78 $\pm 2.1^b$	330.71 $\pm 2.5^b$	342.66 $\pm 2.1^b$	344.46 $\pm 2.5^b$	341.04 $\pm 2.9^b$
Hydro methanolic extract treated group	315.23 $\pm 2.2^b$	298.29 $\pm 2.1^c$	256.24 $\pm 1.7^c$	178.43 $\pm 2.0^c$	107.71 $\pm 1.9^c$

Data are expressed as Mean ± SE; n = 6. Different superscripts (a, b, c,) in each vertical column significantly differ from in each other ($p < 0.05$).

Fasting Blood Glucose: There was significant elevation in fasting blood glucose level was noted in diabetic group in compare to control group. When the diabetic rats were treated with hydro-methanolic extract of leaf of *A. augusta*. This parameter was significantly recovered towards the control level **Table 2**.

Serum Insulin and Glycated Hemoglobin Level: Serum insulin level was decreased but simultaneously glycated hemoglobin level was elevated significantly in diabetic group in compared to control group. Both these two parametes were significantly recoverd towards the control level after the treatment of hydro-methanolic extract of leaf of *A. augusta* to the diabetic rats **Fig. 1**.

Hepatic Hexokinase and Glucose-6-phosphate dehydrogenase Activity: Hepatic hexokinase and Glucose-6-phosphate dehydrogenase activities were diminished significantly in diabetic group in compared to control group. Significant recovery of these parameters was noted after the treatment of the hydro-methanolic extract of leaf of *A. augusta* in diabetic rats **Fig. 2**.

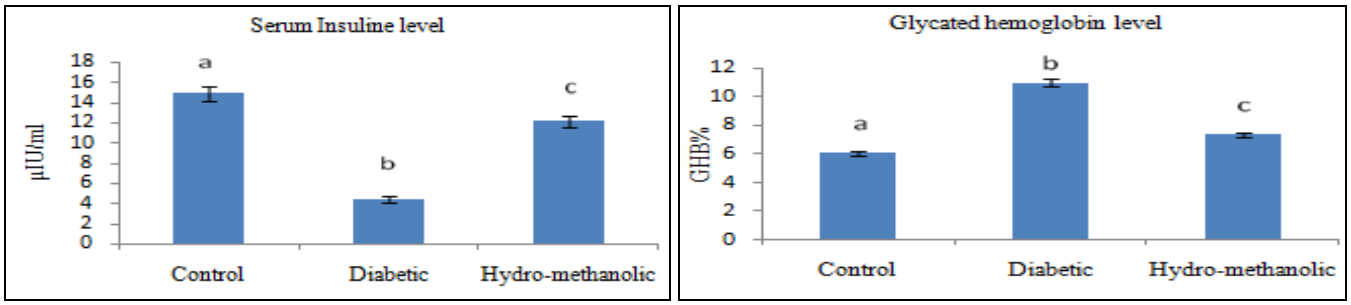

FIG. 1: RECOVERY OF SERUM INSULIN AND GLYCATED HEMOGLOBIN LEVEL AFTER THE TREATMENT OF HYDRO-METHANOLIC EXTRACT OF LEAF OF *A. AUGUSTA*. Data are expressed as Mean ± SE; n = 6. Each bars with different superscripts (a, b, c) differ from in each other significantly ($p < 0.05$).

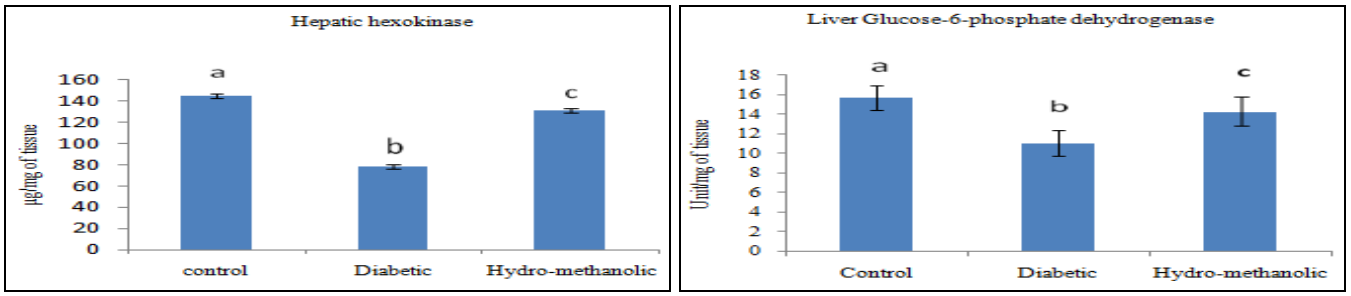

FIG. 2: EFFECT OF HYDRO-METHANOLIC EXTRACT OF LEAF OF *A. AUGUSTA* ON HEPATIC HEXOKINASE AND GLUCOSE-6-PHOSPHATE DEHYDROGENASE ACTIVITIES IN MALE RAT. Data are expressed as Mean ± SE; n = 6. Bars with different superscripts (a, b, c) significantly differ from in each other ($p < 0.05$).

Catalase and Peroxidase: Hepatic catalase and peroxidase activities were significantly diminished in the diabetic group in respect to control group. After administration of hydro-methanolic extract of leaf of *A. augusta*, both these antioxidant enzyme activities were increased towards the control level **Fig. 3**.

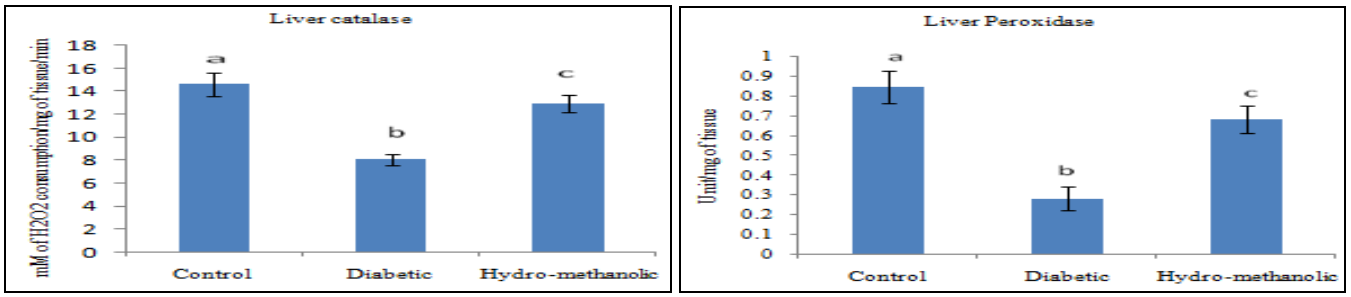

FIG. 3: CHANGES IN HEPATIC CATALASE AND PEROXIDASE ACTIVITIES IN HYDRO-METHANOLIC EXTRACT OF LEAF OF *A. AUGUSTA* TREATED DIABETIC RAT. Data are expressed as Mean ± SE; n = 6. Bars with different superscripts (a, b, c) significantly differ from in each other ($p < 0.05$).

CD and TBARS: Oxidative stress parameters CD and TBARS levels were elevated in STZ induced diabetic rats in compared to the control rats. After the treatment of hydro-methanolic extract of leaf of *A. augusta* for 28 days significant diminution in CD and TBARS levels were noted in compared to the diabetic group **Fig. 4**.

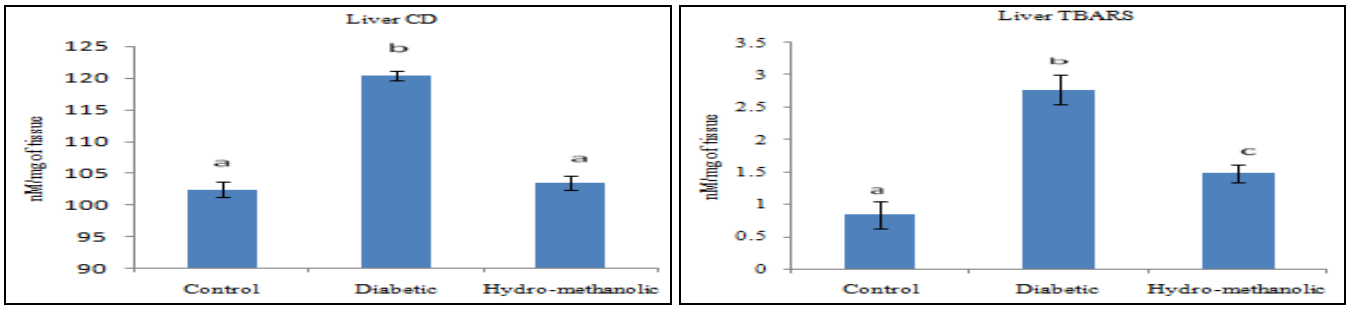

FIG. 4: EFFECT OF HYDRO-METHANOLIC EXTRACT OF LEAF OF *A. AUGUSTA* ON HEPATIC CD AND TBARS LEVELS IN DIABETIC MALE RAT. Data are expressed as Mean ± SE; n = 6. Bars with different superscripts (a, b, c) significantly differ from in each other ($p < 0.05$).

SGOT and SGPT: SGOT and SGPT levels were elevated in STZ induced diabetic rats when compared with control rats. After the treatment of hydro-methanolic extract of leaf of *A. augusta* the SGOT and SGPT activities were diminished towards control level **Fig. 5**.

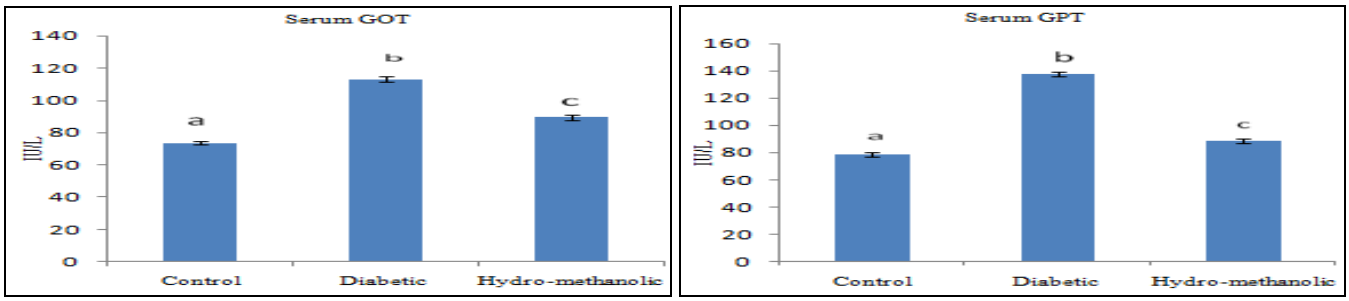

FIG. 5: EFFECT OF HYDRO-METHANOLIC EXTRACT OF LEAF OF *A. AUGUSTA* ON SERUM GOT AND GPT LEVELS
Data are expressed as Mean ± SE; n=6. Bars with different superscripts (a, b, c) significantly differ from in each other ($p<0.05$).

Histology of Pancreas: Cell density of pancreatic islets, count of islets and diameter of pancreatic islets were decreased in STZ induced diabetic rat in compare to control. After the treatment of hydro-methanolic extract of leaf of *A. augusta* to the diabetic animals resulted a marked recovery of these parameters towards the control level **Table 3**, **Fig. 6A - 6C**.

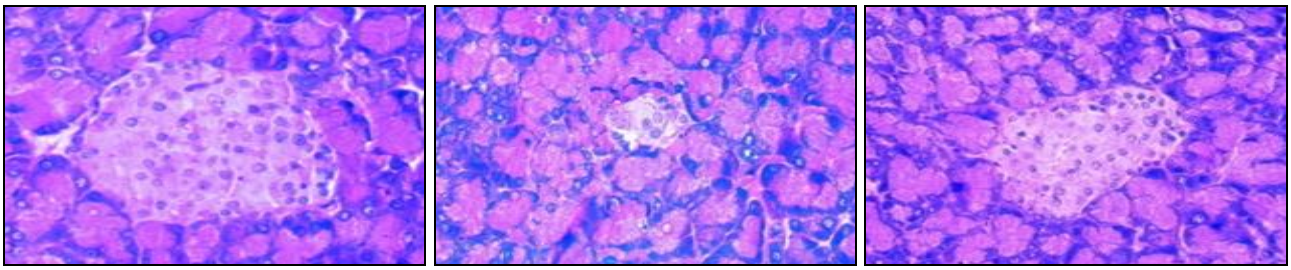

FIG. 6: HISTOLOGY OF PANCREAS, X 400 (HAEMATOXYLIN-EOSIN STAIN)
A- Control Group: Normal cell density along with normal islets size. B- Diabetic Group: Cell density along with islets size was decreased. C- Hydro-methanolic extract treated Group: Cell density and islets size both are increased towards control.

TABLE 3: EFFECT OF HYDRO-METHANOLIC EXTRACT OF LEAF OF A. AUGUSTA ON ISLET NUMBER, ISLET CELL NUMBER AND DIAMETER OF ISLETS IN STREOTOZOTOCIN INDUCED DIABETIC MALE ALBINO RAT

	Islet number count per field in 1000 X magnification	Number of islet cells/ islet	Diameter of islet
Control	22.06±1.42[a]	181.2±8.4 [a]	286.8±11.8[a]
Diabetic	6.92±1.02[b]	75.9±6.8[b]	126.6±9.8[b]
Hydro-methanolic extract treated group	17.41±1.32[c]	162.4±8.2[c]	266.9±11.1[c]

Data are expressed as Mean ± SE; n=6. Different superscripts (a, b, c,) in each vertical column significantly differ from in each other ($p<0.05$).

DISCUSSION: The present study was conducted to determine the antihyperglycemic and antioxidative properties of hydro-methanolic extract of leaf of *A. augusta* in STZ induced male albino rat. The specific dose and duration of experiment adopted had been selected by trial and error study. For such assessment we have studied the fasting blood glucose levels, glycated hemoglobin along with hexokinase and glucose-6-phosphate dehydrogenase activities in liver as well as histoarchitecture of pancreus and serum insulin level. Hepatic catalase, peroxidase enzyme activities, CD and TBARS levels of all experimental groups were assessed as diabetes is strongly associated with oxidative stress [25]. Fasting blood glucose levels were recovered significantly after the treatment of hydro-methanolic extract treatment to the diabetic animals. This may be due to recovery of insulin in extract treated group. Glycated haemoglobin plays an important role in diabetic patient [26]. We measured the glycated hemoglobin levels in different groups and the level was elevated in diabetic group which is consistent with other report [27]. After the treatment of extract there was significant recovery of this parameter was noted. Hexokinase plays an important role for glucose utilization through glycolytic path way [28].

In hepatic tissue this enzyme activity were decrease in diabetic rat that supported by other [13]. Extract treatment resulted significant recovery of this enzyme which results elevation in glucose utilization. Glucose-6-phosphate dehydrogenase is an important enzyme in pentose phosphate pathway for maintenance of normal blood glucose level. Activity of this enzyme decreases significantly in diabetic rats as this enzyme is also under the control of insulin [29] and STZ destroy β-cell of pancreas [30]. This result also supported by our previous work [13].

After the administration of extract these enzyme activities were significantly increased by increased secretion of insulin [29]. Pancreatic *β*-cell regenerative effect of this extract was noted in this study by the rise in serum insulin as well as recovery in volume and diameter of islets found in microphotography. Diabetes is also associated with lipid peroxidation [31] as insulin secretion is closely associated with it. Elevated level of lipid peroxidation leads to islets cell damage in diabetes [32] that diminishes insulin secretion which has been supported by serum insulin levels [33] and histological study of pancreas. Diminution of catalase and peroxidase antioxidant enzyme activities and elevation of CD and TBARS levels in hepatic tissue in diabetic rats also supported by other [34]. Administration of extract results significant restoration of antioxidant enzyme activities as well as CD and TBARS levels in hepatic tissue. These hydro-methanolic extract of leaf *A. augusta* has no general toxicity as body weight remain normal in extract treated diabetic group and there was no change in activities of SGOT and SGPT in extract treated group. From this discussion it may be concluded that the hydro-methanolic extract of leaf of *A. augusta* has a significant protective effect against diabetes induced complications.

CONCLUSION: Hydro-methanolic extract of leaf of *A. augusta* have diabetic therapeutic efficacy by regeneration of pancreatic *β*-cell so the insulin level is increase that rectify fasting blood glucose level, glycated heamoglobin, carbohydrate metabolic enzymes and oxidative stress markers. Another mode of action may be that extract have antioxidant properties by which it may recover the diabetes induced oxidative stress. Further work is going on in our laboratory to search out the effective ingredient(s) present in the extract.

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CONFLICT OF INTEREST: The authors declare no conflict of interest.

REFERENCES:

1. Broderstad AR and Melhus M: Prevalence of metabolic syndrome and diabetes mellitus in Sami and Norwegian populations. The Saminor a cross-sectional study. BMJ OPEN journal 2016; 6: e009474-e009483.
2. Chawla A, Chawla R and Jaggi S: Microvascular and macrovascular complications in diabetes mellitus: Distinct or continuum? Indian Journal of Endocrinology and Metabolism 2016; 20: 546-51.
3. WHO. Global Report on Diabetes. World Health Organization, Geneva; 2016.
4. Acharya AB, Satyanarayan A and Thakur SL: Status of association studies linking diabetes mellitus and periodontal disease in India. International Journal of Diabetes in Developing Countries 2010; 30: 69-74.
5. Zhang C, Caldwell TA, Mirbolooki MR, Duong D, Park EJ and Chi NW, Chessler SD: Extracellular CADM1 interactions

influence insulin secretion by rat and human islet β-cells and promote clustering of syntaxin-1.American Journal of Physiology Endocrinology and Metabolism 2016; 310: E874-E885.
6. Abadpour S, Göpel SO, Schive SW, Korsgren O, Foss A and Scholz H: Glial cell-line derived neurotrophic factor protects human islets from nutrient deprivation and endoplasmic reticulum stress induced apoptosis. Sci Reports 2017; 7: 1-10.
7. Gupta RC, Chang D, Nammi S, Bensoussan A , Bilinski K and Roufogalis BD: Interactions between antidiabetic drugs and herbs: an overview of mechanisms of action and clinical implications. Diabetology and Metabolic Syndrome 2017; 9: 1-12.
8. Way KL, Hackett DA, Baker MK and Johnson NA: The Effect of Regular Exercise on Insulin Sensitivity in Type 2 Diabetes Mellitus: A Systematic Review and Meta-Analysis. Diabetes and Metabolism J 2016; 40: 253-271.
9. Yaryura-Tobias JA, Pinto A and Neziroglu F: Anorexia, nervosa, diabetes mellitus, brain atrophy and fatty liver. The International Journal of Eating Disorder 2001; 30: 350-353.
10. Gandhi GR and Sasikumar P: Antidiabetic effect of *Merremia emarginata* Burm. F. in streptozotocin induced diabetic rats. Asian Pacific J of Tropical Biomedicine 2012; 2: 281-286.
11. Gupta B, Nayak S and Solanki S*: Abroma augusta* Linn f: A review. Pelagia Research Library 2011; 2: 253-261.
12. Nahar L, Ripa FA, Zulfiker AHM, Rokonuzzaman M, Haque M and Islam KMS: Comparative study of antidiabetic effect of *Abroma augusta* and *Syzygium cumini* on alloxan induced diabetic rat. Agriculture and Biology Journal of North America 2010; 1: 1268-1272.
13. Mallick C, Chatterjee K, GuhaBiswas M and Ghosh D: Antihyperglycemic effects of separate and composite extract of root of *Musa paradisiaca* and leaf of *Coccinia indica* in streptozotocin-induced diabetic male albino rat. African Journal of Traditional, Complementary and Alternative Medicines 2007; 4: 362-371.
14. Senthilkumar P, Sudha S and Prakash S: Antidiabetic activity of aqueous extract of Padina Boergesenii in streptozotocin-induced diabetic rats. International Journal of Pharmacy and Pharmaceutical Sci 2014; 6: 418-422.
15. Sherwani SI, Khan HA, Ekhzaimy A, Masood A and Sakharkar MK: Significance of HbA1c test in diagnosis and prognosis of diabetic patients. Biomarker Insights 2016; 11: 95-104.
16. Fraga A, Moraes J, da Silva JR, Costa EP, Menezes J, da Silva Vaz I Jr, Logullo C, da Fonseca RN and Campos E: Inorganic polyphosphates regulate hexokinase activity and reactive oxygen species generation in mitochondria of rhipicephalus (boophilus) microplus embryo. International Journal of Biological Science 2013; 9: 842-852.
17. Sarker SK, Islam MT, Eckhoff G , Hossain MA, Qadri SK, Muraduzzaman AKM, Bhuyan GS, Shahidullah M, Mannan MA, Tahura S, Hussain M, Akhter S, Nahar N, Shirin T, Qadri F and Mannoor K: Molecular Analysis of glucose-6-phosphate dehydrogenase Gene Mutations in Bangladeshi Individuals. PLOS ONE 2016; 10: 1-13.
18. Iwase T, Tajima A, Sugimoto S, Okuda K, Hironaka I, Kamata Y, Takada K and Mizunoe Y: A simple assay for measuring catalase activity: A Visual Approach. Scientific Reports 2013; 3: 3081-3084.
19. Krainer FW and Glieder A: An updated view on horseradish peroxidases: recombinant production and biotechnological applications. Applied Microbiology and Biotechnology 2015; 99: 1611–1625.
20. Haddouche M, Meziane W, Hadjidj Z, Mesli N and Aribi M: Clinical association of baseline levels of conjugated dienes in low-density lipoprotein and nitric oxide with aggressive B-cell non-Hodgkin lymphoma and their relationship with immunoglobulins and Th1-to-Th2 ratio. Indian Journal of Medical Sciences 2016; 7: 111-119.
21. Sharifzadeh M, Ranjbar A, Hosseini A, Khanavi M:The Effect of Green Tea Extract on Oxidative Stress and Spatial Learning in Streptozotocin-diabetic Rats. Iranian Journal of Pharmaceutical Research 2017; 16: 201-209.
22. Wang HL, Chu CH, Tsai SJ and Yang RJ: Aspartate aminotransferase and alanine aminotransferase detection on paper-based analytical devices with inkjet printer-sprayed reagents. Micromachines 2016; 7: 1-10.
23. Chan JKC: The Wonderful Colors of the Hematoxylin–Eosin Stain in Diagnostic Surgical Pathology. International Journal of Surgical Pathology 2014; 22: 12-32.
24. Arkkelin D: Using SPSS to Understand Research and Data Analysis. Psychology Curricular Materials 2014; 1: 1-195.
25. Jana K, Chatterjee K, Ali KM, De D, Bera TK and Ghosh D: Antihyperglycemic and antioxidative effects of the hydro-methanolic extract of the seeds of *Caesalpinia bonduc* on streptozotocin-induced diabetes in male albino rats. Pharmacological Research 2011; 4: 57-62.
26. Sherwani SI, Khan HA, Ekhzaimy A, Masood A and Sakharkar MK: Significance of HbA1c Test in Diagnosis and Prognosis of Diabetic Patients. Biomarker Insights 2016; 11: 95-104.
27. Khan R, Ali K, Khan Z and Ahmad T: Lipid profile and glycosylated hemoglobin status of gestational diabetic patients and healthy pregnant women. Indian Journal of Medical Science 2012; 66: 149-154.
28. Guo X, Li H, Xu H ,Woo S, Dong H, Lu F, Lange A J and Wu C: Glycolysis in the control of blood glucose homeostasis. Acta Pharma Sinica B 2012; 2: 358-367.
29. Taniguchi M, Mori N, Iramina C and Yasutake A: Elevation of Glucose 6-Phosphate Dehydrogenase Activity Induced by Amplified Insulin Response in Low Glutathione Levels in Rat Liver. The Scientific World Journal 2016; 1-7.
30. Cheng Y, Kang H, Shen J, Hao H, Liu J, Guo Y, Mu Y and Han W: Beta-cell regeneration from vimentin+/MafB+ cells after STZ-induced extreme beta-cell ablation. Scientific Reports 2015; 5: 469-478.
31. Mallick C, Bera TK, Ali KM, Chatterjee K and Ghosh D: Diabetes-induced Testicular Disorders Vis-a-vis Germ Cell Apoptosis in Albino Rat: Remedial Effect of Hexane Fraction of Root of *Musa paradisiaca* and Leaf of *Coccinia indica*. J of Health Science 2010; 56: 641-654.
32. Ullah A, Khan A and Khan I: Diabetes mellitus and oxidative stress-A concise review. Saudi Pharmaceutical Journal 2016; 24: 547-553.
33. Reinbothe TM, Safi F, Axelsson AS, Mollet IG and Rosengren AH: Optogenetic control of insulin secretion in intact pancreatic islets with β-cell-specific expression of Channelrhodopsin-2. Islets 2014; 6: e280951-e280958.
34. Rao NK, Bethala K, Sisinthy SP and Manickam S: Antihyperglycemic and *in vivo* antioxidant activities of *Phyllanthus watsonii* A. Shaw Roots in Streptozotocin Induced Type 2 Diabetic Rats. International Journal of Pharmacognosy and Phytochemical Res 2016; 8: 335-340.

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