Turkish Online Journal of Qualitative Inquiry (TOJQI)
Volume 12, Issue 7, July 2021: 9076 - 9086

Research Article

Antidiabetic activity of methanolic extracts of Globba marantia in Streptozotocin induced diabetic rats

Ankush Johar [a], Ajit Kumar Swami [b] , Ankita Anand [a] , Neha Kumari [a] , Ashish Kumar Sharma [a] and Manas Mathur *[c]

a. School of Biotechnology, Mewar University , Chittorgarh, Rajasthan
b. Seminal Applied Sciences Pvt. Ltd. Tonk Road, Jaipur , Rajasthan
c. School of Agriculture, Suresh Gyan Vihar University, Jagatpura, Jaipur, Rajasthan

Abstract

Globba marantia, a broadly practiced plant species in India, has tremendous nutritional value as it has vital food ingredients having therapeutic potential to combat rheumatism, snake bites, and disorders caused due to microbial infection. In current investigation , we studied the antidiabetic potential of methanol extracts of leaves of *G. marantia* in streptozotocin (STZ)-stimulated diabetic albino rats. Rats were administrated with streptozotocin to induce diabetes and further treated with 300 mg⁄ kg plant extract for 3 weeks to observe the reduction in diabetes by observing variations in biochemical parameters in the serum and pancreatic tissue. Phytochemical screening revealed the presence of various metabolites. The succession of diabetes was tremendously decreased after administration of plant extracts. In rats administrated with plant dose , there was noteworthy decrease in serum glucose and nitric oxide, with simultaneous enhance in serum insulin and protein concentrations. Furthermore, plant extracts enhanced free radical scavenging potential in pancreatic tissue, with simultaneous reduction in concentration of thiobarbituric acid-reactive molecules. Histological observation of the pancreas from diabetic rats revealed degenerative variations in β-cells. In mice treated with plant extracts showed the histoarchitectural rejuvenation in islets cells. Thus we assumed that *G. marantia* possessed tremendous antidiabetic and antioxidant potential and some phytochemical may be isolated for analysis in future clinical trials.

Keywords: Antidiabetic; histopathology; *Globa marantia* ; Streptozotocin.

INTRODUCTION

Diabetes mellitus is a chronic disease that has occurred severe effects at global level. A huge population suffering from diabetes globally (Lin and Sun 2010).Many researches elucidated the role of metals in glucose metabolism and their deficiency with diabetes. Diabetes is continuously elevating at rapid rate and leading in mortality of around 5.3 million by the year of 2021 in North Africa, South East Asia,

Europe, Middle East, Caribbean, North America, South and Central America and Western Pacific countries (Cho et al., 2018)

Around 91% diabetes are noninsulin-dependent (NIDDM), thus recommended as type-2 diabetes (T2D). The key root cause of this disease is living and eating habits including food supplements including drinking of alcohol, no physical exercise, smoking, and no consumption of fruits, salads vegetables and herbal products (Kuruppu et al., 2019).

NIDDM is also intricated by insulin deficiencies , leads in discharge of insulin and reduced glucose absorption and consumption (Shori , 2015) Therefore several cumulative results in diabetes which is a global threat and needs keen attention based on phytochemicals isolated from medicinal plants to fight against this disorder. The ratio of glucose intake reduces by inhibiting α-amylase and α-glucosidase activity and causing reduction in the rate of augmentation of postprandial blood glucose concentrations (Wild et al., 2004). Therefore inhibition of the mode of action of α-amylase and α glucosidase through any kind of inhibitors is one of prominent factor to combat NIDDM (Matsui et al., 2001) Various drugs used to combat diabetes , like miglitol, acarbose, voglibose, may minimize the ingestion tempo of glucose by resisting processing of carbohydrates , resulting in reduction in postprandial serum glucose (DiNicolantonio et al., 2015)

However, a prominent quantity and variety of artificial drugs based on chemistry are having toxicity and side effects (Chaudhary et al., 2017). So the main drawback of these synthetic drugs results in inflammation of gastrointestinal, disorder of stomach, and slackness of the bowels and tooting (Fatima and Nazir et al., 2018) . Another substitute protocol like the addition of natural foods in the diet have different inhibitory mode against α-glucosidase and α-amylase with reduced toxicity. Different medicinal plants have been found potent to the hindrance of starch handling catalysts (Quan et al., 2019)

Globba L. is is one of the prominent genus of the Zingiberaceae. *Globba marantia* are cosmopolitian throughout tropical Asia, spreading from India to southern China, south and east to the Philippines and New Guinea. The plant contains some phyto-chemicals like sterols, flavonoids and also bears some antimicrobial activities. Tuber paste has been recommended on scalp to decrease high temperatures for refrigerant and fever

Materials and Methods

The investigations were carried to observe the antidiabetic potential of methanolic extract of *G. marantia.* The present investigation was approved by ethical committee of the Department of Zoology, University of Rajasthan, Jaipur, Rajasthan, India. Indian National Science Academy, New Delhi recommendations were kept for sustaining and application of animal models. Colony bred, adult, male albino rats of 'wistar strain' (200±30 g) were sheltered in polypropylene cages and sustained under optimum temperature (25±3°C), 12 h light/12 h dark cycle and 35-60% relative humidity. They were provided with standard rats feed in form of pellets procured from Hindustan Lever Ltd, Mumbai and water were given *ad libitum.* Only healthy rats were kept for experiments. All the investigations were conducted in late winters and early spring to avoid seasonal variation, if any.

Drug Preparation

Leaves of *G. marantia* were cleaned, air dried, powdered.. Dried powder (3 kg) was extracted with methanol at room temperature for 48 h, with stirring several times throughout the process. The extract was filtered, concentrated and dried *in vacuo* (25.7 g w/w) to prepare final residue for further process.

Experimental Design

Diabetes was triggered intraperitoneally in rats deprived of food and water were administered with freshly equipped 0.2 ml of streptozotocin to induce diabetes (50mg/kg b. wt. dissolved in 0.1mM sodium citrate buffer) and pH sustained at 4.5. After 3 days of streptozotocin administration, blood glucose was calculated and animals having fasting glucose levels above 250 mg/dl were recommended as diabetic. The group of animals without any doses were injected with 0.1mM sodium citrate buffer only. The hyperglycemic rats consumed 2% glucose solution for the night to trounce the hypoglycemia triggered by streptozotocin. Rats were categorized into 4 groups of 7 rats in each and experiments were as set as prescribed protocol.

Group I (Control group): Rats orally administrated 0.5 ml distill water.

Group II Diabetic group given streptozotocin intraperitonially.

Group III Diabetic rats administrated with methanolic extracts of *G. marantia* which were dissolved in millique water (300 mg/kg b. wt./day) for 28 days.

Group IV Glibenclamide (0.3mg/kg b. wt. /day) dissolved in 0.5 ml distilled water orally administrated to diabetic rats with for 4 weeks.

Biochemical Studies

Biochemical analysis were carried out in adult (6-8 weeks old) mice pancreatic tissue. Following methods were applied for the estimation of various parameters.

Serum Glucose (Trinder 1969; Kaplan 1984; Kaplan and Lavernel, 1983), ***Protein*** (Bradford 1976), ***Glutathione (GSH*)** (Moron et al, 1979), ***Peroxidase Assay (POXA),*** (Chance and Maehly 1955) **,** ***Serum Glutamic Oxaloacetic Transaminase (SGOT), Serum Glutamate Pyruvate Transaminase (SGPT*)** (Thefeld et al.,1974; Wallnofer et al.,1974; Bergmeyer, 1980), ***Lipid Peroxidation*** (Buege and Aust, 1978). The LPO has been expressed as MDA in n mole/ gm tissue (Ohkawa et al, 1979), ***Superoxide Dismutase* (*SOD)*** (Marklund and Marklund., 1974) ***Serum urea*** (Varley, 1980**)**, ***Albumin*** (Corcoran and Duran, 1977), ***Creatinine*** (Varley 1980**)**

Results

Protein, SOD and GSH contents significantly decreased (37.29, 54.49 and 36.23%) while LPO contents increased (277.17%) in kidneys of diabetic rats in contrast to control (**Table-1).** Oral administration of methanolic extracts of selected plants at 300 mg/kg b. wt/day concentration for 21 days revealed perfection in protein, SOD and GSH contents (38.46, 45.56 and 59.35%) whereas LPO content declined significantly (44.34%, 42.34% and 48/89% respectively). Parallel trend was observed in glibenclamide (0.3 mg/kg b. wt/day) administered rats wherein, protein, SOD and GSH levels (33.71, 81.60 & 70.95%, respectively) increased and LPO (53.21, 54.23 and 57.34 %) level decreased significantly as compared to the control. When compared with antidiabetic drug treatment using glibenclamide, the levels of GSH and LPO were at par with that of the methanolic extracts *in* treated rats.

In diabetic rats (Gr II), serum urea as well as glucose levels increased (60.23 & 218.49% respectively) significantly as compared to control (**Table-1**). Oral administration of methanolic extracts of selected

plants extract at 300 mg/kg b. wt/day dose for 21 days reduced extensively the serum urea 27.03, 31.25 and 37.76% and serum glucose levels (38.00, 39.71 and 41.23 % respectively). In comparison to diabetic rats, glibenclamide (0.3 mg/kg b. wt/day) administration results in tremendous reduction in serum urea and serum glucose levels (36.07 & 46.52%, respectively;), which was little better than the plant drug treatment.

Diabetes induction results in enhancement ($p \leq 0.001$) in serum creatinine (411.52%), Serum Glutamic Oxaloacetic Transaminase (SGOT/ AST; 165.74%) and Serum Glutamate Pyruvate Transaminase (SGPT/ALT; 78.20%) while reduction ($p \leq 0.001$) in serum protein and albumin levels (44.88 & 40.22%, respectively) when compared with diabetic group II. Administration of methanolic extracts of selected plants (Gr. III) for 21 days caused extensive decrease in serum creatinine, SGOT (34, 38 and 41 %) and SGPT (34, 32.45 and 37 % respectively) and increase in protein and albumin levels ($p \leq 0.01$; 35.19 & 30.48%, respectively). Glibenclamide (0.3 mg/kg b. wt/day dose) showed extremely vigorous decrease in serum AST and ALT level (58.33 & 41.68%, respectively) and increase in protein and albumin levels (45.12 & 48.36%, respectively; **Table - 2**) in contrast to diabetic rats. The levels of SGPT in glibenclamide treated rats were found to be at par with plant drug treated rats.

Pancreas histopathology

In present study the pancreatic cells were destroyed with the help of streptozotocin. **(Fig.1a to d).** β cells were partially disrupted and the histopathogical analysis of stained β cells proved this. Histopathological study of diabetic control rats showed almost completes destruction of β cells, which was due to the intake of adequate quantity streptozotocin used in current investigation. Pancreatic β cells stimulated by streptozotocin induced of variations thus working as $NO^{\bullet}$ action, i.e. elevated potential of guanylyl cyclase and increased synthesis of cGMP (Turk *et al*, 1993). Methanolic extract administration caused marked regeneration in pancreatic islets. The hypoglycemic effect of plants may be due to the presence of insulin-like substances in plant, stimulation of β cells to produce more insulin and high level of fiber which interferes with carbohydrate absorption.

Discussion

Consumption of medicinal plants is almost equal to mankind origin . The correlation among man and his discovery for novel antidiabetic agents in nature is long lasting , which has been proved by various mentioned documents, conserved monuments, and even pure bioactive compounds originated from medicinal plants. Wakefulness of their consumption has been outcome by years of drawbacks to combat many disorders which forced the living community for search of drugs in different plant parts like fruit bodies, seeds, barks and other parts of the plants. Modern science has recognized their potent application, and which has placed its value in modern pharmacotherapy which includes broad variety of medicinal plants, since ancient era and applied in millennia. Streptozotocin diabetes stimulation results in reduced in β cells quantity and thus stimulates hyperglycemia (Brenna *et al*, 2003). In our present study, it was observed that methanolic extracts of , *G. marantia* reduces serum glucose in diabetic rats. The mechanism by which these extracts brings about its hyperglycemic action is possibly due to insulin secretion caused by enhanced pancreatic insulin discharge from the regenerated β cells or its secretion from bound insulin. So there are many scanty reports on antidiabetic activity of medicinal plants (Gupta & Gupta, 2009).

The concentration of serum albumin in diabetic rats reduced due to extravasations in to urine (Scalia *et al*, 2007). Elevated permeability for albumin is a negative prognostic aspect of vascular disorders. Oral extracts of these plant extracts treatment was significant in improving the serum albumin concentration because of reduced membrane integrity.

Diabetes induced anomalous protein metabolism ultimately resulting in different metabolic diseases and complexities (Goldstein *et al*, 2004). Extracts of plants administration in diabetic rats enhanced serum protein level. This phenomena is related to enhanced insulin production , which assists amino acid uptake, increases protein synthesis and also reduces protein squalor (Rosen *et al*, 1981).
Hsu et al (2020) reported antidiabetic potential *Chamaecyparis obtusa* var. formosana in streptozotocin induced diabetic rats. They reportedthat after 90 days of administration of plant extracts , both LCO and HCO were having improved glucose metabolism in oral glucose tolerance and postprandial blood glucose tests. Reduction in HOMA-IR, leptin and adiponectin amount of the HCO group showed amelioration of insulin and leptin resistance. These therapeutic potential is due to inhibition of intestinal digested enzymes and protein tyrosine phosphatases (PTPases). Wu et al (2021) reported antidiabetic potential of *S. pastorianus* study its molecular mechanisms. Phytochemical analysis of extract revealed the presence of proteins and carbohydratesincluding other phenolic compounds . In diabetic rats, oral administration of *S. pastorianus* extract extensively reduced the concentration of plasma glucose and increased the mode of action of hepatic glucose-6-phosphatase dehydrogenase. Further administration with *S. pastorianus* extract enhanced the localization of type 4 glucose transporter (GLUT4), PTP, and insulin receptor at 3T3-L1 cell membranes and increased the levels of P38 MAPK, PI3K, and AKT in the cytosol. Finally a 54 kDa protein having prominent antidiabetic potential was analysed and found to be major factor in induction of this antidiabetic potential. Sai et al (2021) antidiabetic potential of *Spondias pinnata* (L.f.) Kurz. They reported that *S. pinnata* (500 mg/kg) and metformin (100 mg/kg) possessed tremendous ($p < 0.05$) reduction in concentration of blood glucose at 1, 2, and 3 h in normal rats in contrast to the control group. The group administrated with Metformin- (100 mg/kg)- and *S. pinnata*- (500 mg/kg)- rapid decrease in the blood glucose level at 3 h when observed by oral glucose tolerance test (OGTT). These properties of plant is due to the presence of bioactive compounds that contribute to its antidiabetic potential. Steroids presence in this plant was one of the key constituent responsible for antidiabetic potential by decrease in high blood glucose concentration and restoring insulin levels in streptozotocin-induced diabetic rats (Daisy et al., 2009, Kumar et al., 2011). Further , it has excellent antioxidant potential and partially α-amylase inhibitory activities. α-Amylase is an enzyme assist in digestion of carbohydrates. It hydrolyses α-linked polysaccharides such as starch and glycogen and converts them into simple sugars such as glucose and maltose (Thilagam et al., 2013). Inactivation of this enzyme delays glucose absorption which is decisive therapeutic potential for decreasing postprandial hyperglycemia. Es safi et al (2020) proved antidiabetic potential of hydroethanolic extract of *Ammodaucus leucotrichus Cosson* which was free from fat soluble molecules . They observed that after 30 days the extract improved blood glucose level. Further they showed that HPLC analysis confirmed presence of certain bioactive compounds like gallic acid, luteolin, chlorogenic acid, ferulic acid 3-p-coumaroylquinic acid, myricetin and quercetin which were found to be responsible for this activity Hyun et al (2018) reported antioxidant, antimicrobial, and antidiabetic potential of Crowberry fruits.. The crude 70 % extracts of ethanol, ethyl acetate and butanol possessed strong free radical scavenging assay. Further , the ethyl acetate fraction showed extensive inhibition of α-glucosidase and α-amylase activities. Widiastuti et al (2021) reported antidiabetic potency of ethanol extract and taurine from Jeruju (*Acanthus*

ilicifolius L.) on histopathological effects on kidney induced by alloxan. They reported that leaves and taurine of plant possessed significant free radical scavenging assay including antidiabetic potential. Further they observed that there was regeneration in kidney organs damaged by alloxan.

The results showed that the administration of jeruju extract and taurine affected the bodyweight of mice, and have potential to decrease blood glucose concentration by 69.39% , 67.06% , 73.77% able to rejuvenate kidney damage when administrated by alloxan. The intra-pancreatic mechanism having bioactive compounds like alkaloids and flavonoids were able to rejuvenate the disrupted pancreatic β cells to enhance insulin secretion through sympathetic nerve triggering and protect destroyed nerves pancreatic cells from free radicals . In the extra-pancreatic mechanism, alkaloids and saponins reduced blood glucose by inhibiting glucose absorption in the intestine so that glucose entering the bloodstream decreases, triggering glycogen synthesis and inactivating the enzyme α-glucosidase. The treatment with taurine at 15.6 mg/bw/day results in reduction in the highest glucose level of 73.77%. This compound was having extensive role in the tolerance of blood glucose to control its metabolic processes. High free radical scavenging potential of taurine most probably restrain free radicals from alloxan to reduce blood glucose concentrations. Several reports showed that administration of taurine was able to reduce the blood glucose of alloxan-induced mice (Widiastuti et al., 2017). The main mechanism was that it able to control glucose metabolism through the regulation of gene expression that assists in insulin secretion and enhance peripheral insulin sensitivity. It was also was able to change the factors which results in susceptibility to toxic chemicals and could protect the body from toxicity.

Conclusion

The current investigation outcomes clearly mentions the prospect to synthesize a potent antidiabetic medicines from methanolic extracts of *G. marantia* .

Acknowledgement

The authors are thankful to Heads, Mewar University and Department of Zoology and Seminal applied Sciences for assisting the experimental facilities to carry out the research work including animal models and their kits for biochemical tests.

CONFLICT OF INTEREST

The Authors declared that there are no conflicts of interests

References

[1] Lin, Y., & Sun, Z. (2010). Current views on type 2 diabetes. The Journal of endocrinology, 204(1), 1.

[2] Cho N, Shaw JE, Karuranga S, Huang Y, da Rocha Fernandes JD, Ohlrogge AW, Malanda B (2018) IDF Diabetes Atlas: global estimates of diabetes prevalence for 2017 and projections for 2045. Diabetes Res. Clin. Pract 138: 271–281

[3] Kuruppu AI, Paranagama P, Goonasekara CL (2019) Medicinal plants commonly used against cancer in traditional medicine formulae in Sri Lanka. Saudi Pharm J27(4):565–573

[4] Shori AB (2015) Screening of antidiabetic and antioxidant activities of medicinal plants. J. Integr. Med 13(5):297–305

[5] Matsumoto K (2001) αGlucosidase inhibitory action of natural acylated anthocyanins. Survey of natural pigments with potent inhibitory activity. J. Agric. Food Chem 49(4): 1948–1951

[6] DiNicolantonio JJ, Bhutani J, O'Keefe JH (2015) Acarbose: safe and effective for lowering postprandial hyperglycaemia and improving cardiovascular outcomes. Open heart 2(1):e000327

[7] Chaudhury A, Duvoor C, Reddy Dendi VS, Kraleti S, Chada A, Ravilla R, Marco A, Shekhawat NS, Montales MT, Kuriakose K, Sasapu A (2017) Clinical review of antidiabetic drugs: implications for type 2 diabetes mellitus management. Front Endocrinol 8:6

[8] FatimaM SS, Nazir SU (2018) Metformin and its gastrointestinal problems: A review. Biomed. Res 29:2285–2289

[9] Quan NV, Xuan TD, Tran HD, Thuy NT, Trang LT, Huong CT, Andriana Y, Tuyen PT (2019) Antioxidant, α-amylase and α-glucosidase inhibitory activities and potential constituents of 8Canarium tramdenum bark. Molecules 24(3):605

[10] Trinder P. 1969. Determination of glucose in blood using glucose oxidase with an alternative oxygen acceptor. Ann. Clin. Biochem. 6: 24.

[11] Kaplan A and Lavernel LS. 1983. Lipid Metabolism. In: Clinical Chemistry: Interpretation and Techniques, 2nd ed. Febiger, Philadelphia. pp. 333-336.

[12] Bradford MM. 1976. A rapid and sensitive for the quantitation of microgram quantitites of protein utilizing the principle of protein-dye binding. *Anal. Biochem. 72:* 248-254.

[13] Moron MJ, Depierre JW and Mannivik B. 1979. Levels of glutathione, glutathione reductase and glutathione S-transferase activities in rat lung and liver. Biochem et. Biophys. Acta. 582: 67-68.

[14] Chance B and Maehly AC. 1955. Assay of catalase and peroxidases. Methods. Enzymol. 2: 764 -775.

[15] Thefeld W, Hoffmeister H, Busch EW, Koller PU and Vollmar J. 1974. Referenzwerte fur die Bestimmungen der Transaminasen GOT und GPT sowie der alkalischen Phosphatase im Serum mit optimierten Standardmethoden. Dtsh. Med. Wochenschr. 99:343-51.

[16] Wallnofer H, Schmidt E and Schmidt FW. (Eds.). 1974. Synopsis der Leberkrankheiten. Goerg Thieme Verlag, Stuttgart, Thefeld, Dtsch. Med Wschr. 99: 343.

[17] Bergmeyer HU. 1980. Methods of Enzymatic analysis metabolites. 3rd Ed. Vol. 6 Wiley Publications, UK.

[18] Buege JA and Aust SD. 1978. Methods in Enzymology. Academic Press, New York, USA. 52: pp.302-314.

[19] Ohkawa H, Ohishi N and Yagi K. 1979. Assay for lipid peroxides in animal tissues by thiobarbituric acid reaction. Anal. Biochem. 95: 351-358.

[20] Corcoran R and Duran S. 1977. Albumin determination by a modified bromcresol green method. Clin. Chem. 23: 765-766.

[21] Varley H, Gowelock AH, Bell M. Non-protein nitrogen, urea, creatine and creatinine. In: Practical Clinical Biochemistry, 5th edn, Vol I: General topics and commoner tests. London: Heinemann, 1980; 451-88.

[22] Hsu, C. Y., Lin, G. M., & Chang, S. T. (2020). Hypoglycemic activity of extracts of Chamaecyparis obtusa var. formosana leaf in rats with hyperglycemia induced by high-fat diets and streptozotocin. *Journal of traditional and complementary medicine*, *10*(4), 389-395.

[23] Wu, C. H., Huang, C. H., Chung, M. C., Chang, S. H., & Tsai, G. J. (2021). Exploration of Hypoglycemic Activity of Saccharomyces pastorianus Extract and Evaluation of the Molecular Mechanisms. *Molecules*, *26*(14), 4232.

[24] Sai, K., Chhetri, S. B. B., Devkota, S. R., & Khatri, D. (2021). Evaluation of the Hypoglycemic Potential of Leaves Extract of Spondias pinnata (Lf) Kurz. from Nepal. *The Scientific World Journal*, *2021*.

[25] Daisy P, R. Jasmine, S. Ignacimuthu, and E. Murugan, "A novel steroid from Elephantopus scaber L. an ethnomedicinal plant with antidiabetic activity," Phytomedicine, vol. 16, no. 2- 3, pp. 252–257, 2009.

[26] Kumar A. Yashwant, K. Nandakumar, M. Handral, S. Talwar, and D. Dhayabaran, "Hypoglycaemic and anti-diabetic activity of stem bark extracts Erythrina indica in normal and alloxan-induced diabetic rats," Saudi Pharmaceutical Journal, vol. 19, no. 1, pp. 35–42, 2011.

[27] Thiilagam E , B. Parimaladevi, C. Kumarappan, and S. Chandra Mandal, "*α*-Glucosidase and *α*-amylase inhibitory activity of *Senna surattensis*," *Journal of Acupuncture and Meridian Studies*, vol. 6, no. 1, pp. 24–30, 2013.

[28] Es-Safi, I., Mechchate, H., Amaghnouje, A., Calarco, A., Boukhira, S., Noman, O. M., ... & Bousta, D. (2020). Defatted Hydroethanolic Extract of Ammodaucus leucotrichus Cosson and Durieu Seeds: Antidiabetic and Anti-Inflammatory Activities. *Applied Sciences*, *10*(24), 9147.

[29] Hyun, T. K., Ra, J. H., Han, S. H., & Kim, J. S. (2018). Antioxidant, antimicrobial, and antidiabetic activities of crowberry fruits. *Indian Journal of Pharmaceutical Sciences*, *80*(3), 489-495.

[30] Widiastuti, E. L., Ardiansyah, B. K., Nurcahyani, N., & Silvinia, A. (2021). Antidiabetic Potency of Jeruju (Acanthus ilicifolius L.) Ethanol Extract and Taurine on Histopathological Response of Mice Kidney (Mus musculus L.) Induced by Alloxan. In *Journal of Physics: Conference Series* (Vol. 1751, No. 1, p. 012052). IOP Publishing.

[31] Widiastuti EL, Sutyarso, Susanto GN, Rudini M and Kanedi M. 2017. Ameliorative Properties of Crude Diosgenin from *Costus speciosus* and Taurine on Testicular Disordersin Alloxan- Induced Diabetic Mice. Biomedical & Pharmacology Journal. Vol. 10(1),09-17.

Table – 1 Effect of methanolic extract of selected plants on Protein, GSH, SOD and LPO levels in Streptozotocin induced diabetic Rat kidney

Treatment	Protein (mg g^{-1})	GSH (n mol g^{-1} tissue)	SOD (μ□mol mg^{-1} protein)	LPO (nmol MDA mg^{-1} protein)
Group-I (C)	213.32±13.93	4.25±0.15	10.13±0.59	2.76±0.81
Group-II (D)	133.77^{**} ±8.89	2.71^{**} ±0.26	4.61^{**} ±0.66	10.41^{**} ±0.79
Group-III	183.27 ±17.33	4.29^{nsa++} ±0.19	6.88^{nsa++} ±0.81	5.45^{nsa+a} ±0.61
Group-IV (D+G)	179.82^{nsa} ±11.21	4.66^{nsa++} ±0.18	8.28^{nsa+} ±0.57	4.87^{nsa+} ±0.31

Each value is mean of seven replicates ± SE; Diabetic group is compared with normal group; experimental groups are compared with normal and diabetic group; values are statistically significant at $^{*}P< 0.05$; $^{**}P\leq 0.001$, as compared with the normal control; $^{a}P< 0.05$; $^{a+}P\leq 0.01$; ^{ns} non-significant.

*Where - **Group-I** - Control (vehicle treated); **Group-II** - Diabetic group**; Group-III** - Diabetic + G. marantia (300mg/kg b.wt./day); **Group-IV** - Diabetic + Glibenclamide (0.3mg/kg b.wt./day)*

Table – 2 Effect of methanolic extract of selected plant parts on biochemical levels and Serum SGOT, SGPT levels after 21 days treatment in Streptozotocin induced diabetic Rats

Treatment	Serum urea (mg/dl)	Creatinine (mg/dl)	Glucose (mg/dl)	Total protein (mg/dl)	Albumin (mg/ 100ml)	SGOT (IU L^{-1})	SGPT (IU L^{-1})
Group-I	27.22 ±1.43	0.84 ±.024	81.78 ±12.84	6.84 ±0.32	3.53 ±0.19	11.21 ± 2.12	14.87 ± 0.77
Group-II	43.55^{**} ±1.37	4.28^{**} ±0.19	261.28^{**} ±3.2	3.77^{**} ±0.17	2.11^{**} ±0.10	29.23^{**} ± 2.02	25.31^{**} ± 1.01
Group-III	33.56^{a++} ±0.78	2.00^{*a+} ±0.22	158.37^{*a++} ±32.78	5.18^{*a+} ±0.21	2.43^{nsa+} ±0.08	16.28^{*a++} ± 0.91	16.99^{nsa++} ± 0.88
Group-IV	28.28^{*a+} ±0.76	0.93^{nsa++} ±0.48	141.54^{nsa++} ±14.61	5.43^{*a++} ±0.24	3.11^{nsa} ±0.24	12.18^{*a++} ± 0.78	14.76^{*a++} ± 0.81

Each value is mean of seven replicates ± SE; As compared with control rats ($^{*}P\leq 0.01$; $^{**}P\leq 0.001$), as compared with hyperglycemic rats ($^{a}P<0.01$); ^{ns}non-significant.

*Where - **Group-I** - Control (vehicle treated); **Group-II** - Diabetic group**; Group-III** - Diabetic + G. marantia (300mg/kg b.wt./day); **Group-IV** - Diabetic + Glibenclamide (0.3mg/kg b.wt./day); SGOT- Serum Glutamic Oxaloacetic Transaminase, SGPT - Serum Glutamate Pyruvate Transaminase.*

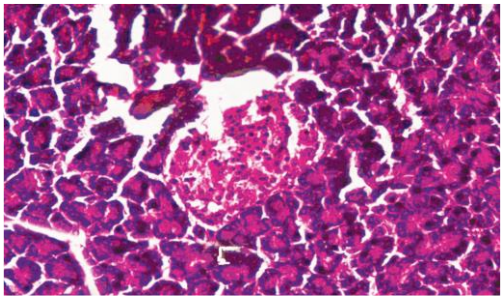

Fig 1 ***Control*** **- Rat pancreas section (21 days) showing normal histoarchitecture with prominent cytoplasm, islet cells in pancreatic islet with centroacinar cells containing serous acini (X 400**

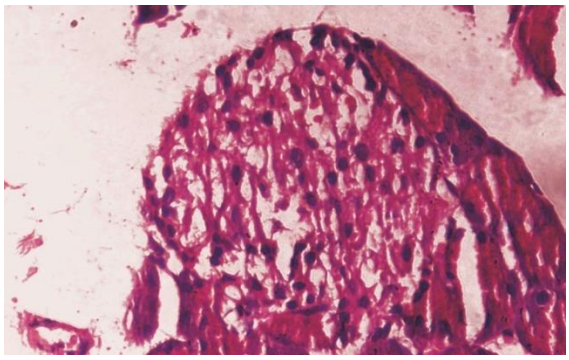

Fig. 2 ***Diabetic Control or Streptozotocin Treated*** **- Rat pancreas section (21 days) showing ruptured pancreatic islet with degenerated pancreatic cells. Disintegrated centroacinar cells contain increased intercellular space and cellular debris (X 400).**

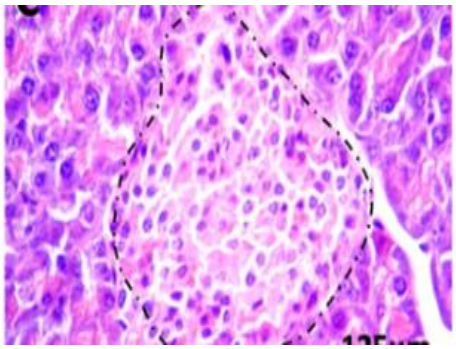

Fig. 3 ***Diabetic Rats Orally Treated MF of leaves of G. marantia*** **– Pancreas section (21 days) showing markedly rejuvenated cytoplasm with normal pancreatic islet. Increased number of islet cells is clearly visible. Centroacinar cells in serous acini are also present (X 400).**

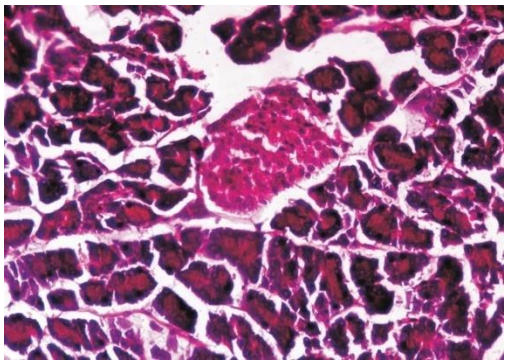

Fig. 4 ***Diabetic Rats Orally Treated with Glibenclamide*****- Pancreas section (21 days) showing normal islet histoarchitecture with increased number of islet cells though with cytoplasmic lesion, centroacinar cells in serous acini (X 400).**