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Ocimum Gratissimum Alleviates Derangements in Serum and Biliary Bilirubin, Cholesterol and Electrolytes in Streptozotocin- Induced Diabetic Rats

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Authors' contributions

This work was carried out in collaboration between all authors. Author OUA conception and design, experimentation and acquisition of data, interpretation of data and coordination. Author IDE preparation of draft manuscript and managed the literature searches, statistical analysis, author BEE experimental design, experimental coordination and interpretation of data. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

Aims: The effects of oral administration of aqueous leaf extract of Ocimum gratissimum (OG) on biliary and serum bilirubin, cholesterol and electrolytes in streptozotocin (STZ)-induced diabetic Albino Wistar rats was studied.
Methodology: Type 1 Diabetes mellitus was induced in the test groups (DM and DMT) by a single dose of STZ (65 mg/kg, i.p.). The phytoconstituents and median lethal dose of the plant extract was determined before administration. The extract was administered per oral to the DMT group at a dose of 1500 mg/kg body weight daily for 28 days. All the groups were fed normal rat chow and allowed water ad libitum. Biliary secretion was collected and assayed, biliary bilirubin was measured by colorimetric method, Sodium and potassium was determined using a flame photometer and Chloride was determined by end point calorimetric titration.

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Results: The result showed that serum cholesterol was significantly (p=.001) higher in the DM group compared to the control while the DMT group was significantly (p=.001) lower than the DM group. Serum conjugated and unconjugated bilirubin were significantly (p=.05, p=0.01) higher in the DM group compared to the control and DMT groups, with the DMT group significantly (p=.01) lower than the DM group. The serum electrolytes showed no significant change in K^+. However, Cl^- and HCO_3^- were significantly (p=.001) reduced in the test group compared to the control. Na^+ was significantly raised in the DMT group compared to the control.
Conclusion: These results are indicative of the efficacy of Ocimum gratissimum to obviate the derangement in biliary and serum bilirubin, cholesterol and electrolytes caused by the STZ-induced type 1 DM in albino wistar rats.

Keywords: Ocimum gratissimum; diabetes mellitus; electrolytes; cholesterol; bilirubin.

1. INTRODUCTION

Arrays of multisystem complications are known to be associated with both type I and II DM; including alterations in the function of the hepatobiliary and renal systems. The most common disease associated with DM in the biliary system, is the formation of gallstones. The pathogenesis of cholesterol gallstone formation is complex and many factors are involved, such as changes in bile composition (cholesterol, bile acids, and phospholipids), changes in gall bladder motility and the presence of nucleation promotion factors. Diabetics have abnormal serum lipid profiles and increased biliary cholesterol secretion, resulting in increased cholesterol saturation of bile [1,2]. Elevated plasma insulin has been associated with an increased prevalence of gallstone disease [2] and may account for the strong association between, Type 2 Diabetes Mellitus and gall stones.

Elevated levels of glucose, free fatty acids, hyperinsulinaemia and insulin resistance are the pathological basis for the development of diabetes mellitus complications. Glucotoxicity and lipotoxicity has been referred to as the diabetogenic effects of increasing blood levels of glucose and free fatty or increased cellular fat content respectively [3]. Lipotoxicity is a common feature in diabetes mellitus and it has a strong association with obesity. It is also believed that excess fuel in form of fat may be responsible for rising blood glucose concentration [3]. Several explanations for lipotoxicity have emerged. An explanation for lipotoxicity involves the Randle (glucose – fatty acid) cycle [4]. According to this hypothesis, fatty acid glucose oxidation can be thought of as competitive in the sense that excess fat metabolism impairs the oxidation of glucose. The formation of acetyl coenzyme A (CoA), a product of both glucose and fat oxidation meditates this process of glucose impairment. Acetyl CoA inhibits glucose use by allosteric inhibition of pyruvate dehydrogenenase, the enzyme complex used for pyruvate conversion to acetyl CoA, the last step in delivery of glycolytic fuel to mitochondria [3,4].

Other explanations for lipotoxicity involve fatty acid inhibition of cellular glucose entry through the inhibition of one or more steps in the insulin-signalling cascade. Free fatty acids may impair GLUT4 gene expression in muscle and fat [5]. In addition, free fatty acids decrease glucose conversion into glycogen for storage, while also causing increase hepatic glucose output from gluconeogenesis [5,6]. There seems to be a kind of competition between glucose and fat in that not only does fat oxidation impair glucose uptake and metabolism, but glucose itself can inhibit fat utilization [3].

Alterations in the function of the liver, biliary system and exocrine pancreas are common in DM. However, in contrast to other systemic disorders with GI involvement; symptoms originating from these organs are less prominent, apart from biliary colic due to gallstones.

Electrolytes play an important role in many body processes, such as controlling fluid levels, acid-base balance (pH), nerve conduction, blood clotting and muscle contraction [7]. Electrolyte imbalance in diabetes is primarily a result of elevated blood glucose. With hyperglycemia, the body tries to rid itself of the excess blood glucose by increasing urinary output. Increased urination produces water and electrolyte loss, which then upsets the body's balance of electrolytes. The balance is especially disturbed between sodium and potassium [8]. Electrolyte imbalance resulting from kidney failure, dehydration, fever and vomiting has been suggested as one of the contributing factors toward complications observed in diabetes and other endocrine disorders [7].

Ocimum gratissimum is one of the species from the genus Ocimum. It is commonly called African basil or shrubby basil [9]. OG is a genus of about thirty five species of aromatic annual and perennial herbs and shrubs in the family Lamiacae. It is widely distributed in tropical and warm temperate regions. It has a strong taste with characteristic flavour. It is used commonly by the various tribes of Nigeria for nutritional and medicinal purposes. It is called “Nton” in Ibibio/Efik, “Efinrin” in Yoruba, “Daidoya” in Hausa and “Nchonwu” in Igbo.

Phytochemical analysis revealed important constituents as tannins, alkaloids, saponins, flavoniods and phenolic compounds [10]. The volatile aromatic oil from the leaves of this plant consists mainly of thymol (32-65 per cent) and eugenol: it also contains xanthones, terpenes, and lactones [11]. Also citral, ethyl cinnamate, geraniol and linalool have also been extracted from this oil [12].

The hypoglycemic properties of OG claimed by Nigerian traditional herbal medicine practitioners had been investigated and confirmed to be true [13, 14] but there is paucity of data on the effect of DM on biliary and serum bilirubin, cholesterol and electrolytes, these study therefore set out to determine if DM affect these parameters and if OG could ameliorate these effects (if any).

2. MATERIALS AND METHODS

2.1 Plant materials and Preparation of Aqueous Extract

The leaves of Ocimum gratissimum were obtained from the University of Calabar Botanical Garden and identified by the Chief Herbarium Officer of Botany Department of University of Calabar. The fresh leaves were rinsed with water to remove sand and debris and then allowed to air dry. The leaves were then dried under shade for two days and then transferred into AstellHearson Oven and dried at a temperature range of 40 – 45ºC.

The dried leaves were then ground in an electric blender into fine powder to give a gram weight of 527grams. This 527g weight was soaked in 2.65 liters of water (distilled water) and was soaked overnight for about 15 hours and stirred at regular intervals. The mixture was filtered using a satin mesh material and the final filtrate was gotten by using Whatman’s filter paper size 1. The final filtrate was dried in the Astell Hearson Oven at 45ºC to obtain a brown gummy paste. A mettler P163 electronic weighing balance was used to weigh the

gummy paste before stock solution was prepared. The stock solution of the extract was prepared by dissolving 15gm of extract in 10ml of water to give a concentration of 1500mg/ml. The stock solution was labeled appropriately and refrigerated at 4ºC until required for use. The median lethal dose (LD_{50}) of the plant extract was determined by method of Lorke [15].

2.1.1 Determination of phytoconstituents

The phytoconstituents of the extracts was determined and were screened for the presence of carbohydrates, tannins, alkaloids, saponins, phenolics, anthraquinones and cardiac glycosides as described by Trease and Evans [16] and Sofowora [17].

2.2 Animals Preparation, Experimental Groupings and Treatment

Eighteen male albino wistar rats were used for the study, the animals were divided into three groups and were assigned randomly into each group which was made up of Six (6) rats each and housed in cages assigned to them.

The first group was made up of the control animals which were fed with normal rat chow (feed). The second group contained streptozotocin induced diabetic rat which were left untreated. The third group of animals contained the test group which were streptozotocin induced diabetic rats treated with aqueous leaf extract of Ocimum gratissimum. The experimental procedures involving the animals and their care were in line with the approved guidelines by the local (University of Uyo, Akwa Ibom State) research and ethical committee established and guided by the Helsinki Declaration on Animal research.

2.2.1 Induction of diabetes mellitus

Type I diabetes mellitus was induced in twelve male albino wistar rats by a single injection of 65mg/kg streptozotocin. The injection was given intraperitoneally. The state of diabetes was observed after 48 hours by the symptoms of polyuria and glucosuria and this state was confirmed using uristic test strip (Bayer Health Care LLC, USA). Also, the blood glucose level was tested 1 week after induction using a Glucometer (ACCU-CHECK Advantage II, Roche Diagnostics (GmbH, Germany) and ACCU-CHECK Advantage II test strips.

2.2.2 Extract administration and observation

One week after induction of diabetes in the 12 male albino wistar rats, the extract was administered per oral to the DMT group at a dose of 1500 mg/kg body weight daily for 28 days. Administration was facilitated by the use of a syringe and Orogastic tube.

2.3 Collection of Biliary Secretion

Biliary secretion was collected by the method of Vickers et al. [18]. The male albino wistar rats were starved for 12 hours prior to the time of experiment. The animals were weighed and anaesthesized by intraperitoneal administration of sodium thiopentone (6mg/100g body weight), and were quickly pinned to a dissecting board for a tracheostomy performed to clear the airway for easy breathing. The stomach was opened along the linea alba to prevent bleeding. A laparotomy was performed and the liver lobes deflected anterolaterally to expose the common bile duct. The common bile duct was then Cannulated with a portex Cannula

(0.5mm in diameter) after a small incision was made. The Cannula was held in place with a thread tied round the bile duct. The bile content was collected at 3 hours interval for each group studied.

2.3.1 Determination of biliary and Serum bilirubin

Biliary bilirubin was measured by colorimetric method as described by Jendrassik and Grof, [19] and later Sherlock [20].

2.3.2 Determination of biliary and serum electrolytes: sodium and potassium, bicarbonate, chloride

Sodium and potassium in bile and serum were determined using a flame photometer (Model 410C, Petracourt Ltd, England). Plasma carbon dioxide (CO_2) was measured by the modified method of Forrrester et al. [21]. Biliary and Serum Chloride was determined by end point calorimetric titration following the method of Kolthoft et al. [22].

2.3.3 Determination of biliary and serum cholesterol

Cholesterol was determined using the method of Allain et al. [23].

2.4 Statistical Analysis

All results are presented as mean + standard error of mean. Three sets of data were analyzed using one way ANOVA, followed by the least significant difference (LSD) procedure for significant F values, (P=.05) was considered significant. Computer software SPSS and Excel Analyzer was used for the analysis.

3. RESULTS AND DISCUSSION

3.1 Serum Cholesterol, Total Bilirubin, Conjugated Bilirubin and Unconjugated Bilirubin in the Different Experimental Groups

3.1.1 Serum cholesterol level in the control, DM and DMT groups of experimental rats

The mean cholesterol concentrations were: 0.87 ± 0.013, 1.37 ± 0.091 and 0.9 ± 0.036mmol/L respectively in the control, DM and DMT groups. They were all significantly different. The DM was significantly higher (P=.001) than the control, and the DM was significantly higher (P=.001) than the DMT, Fig. 1.

3.1.2 Estimated total serum bilirubin in the various experimental groups of rats

The mean values for the total serum bilirubin concentration in the control, DM and DMT groups were: 4.1 ± 0.044, 7.6 ± 0.948 and 4.7 ± 0.678 respectively. The DM was significantly higher (P=.001) than the control; while the DMT was significantly lower ($P < 0.05$) than the DM, Fig. 2.

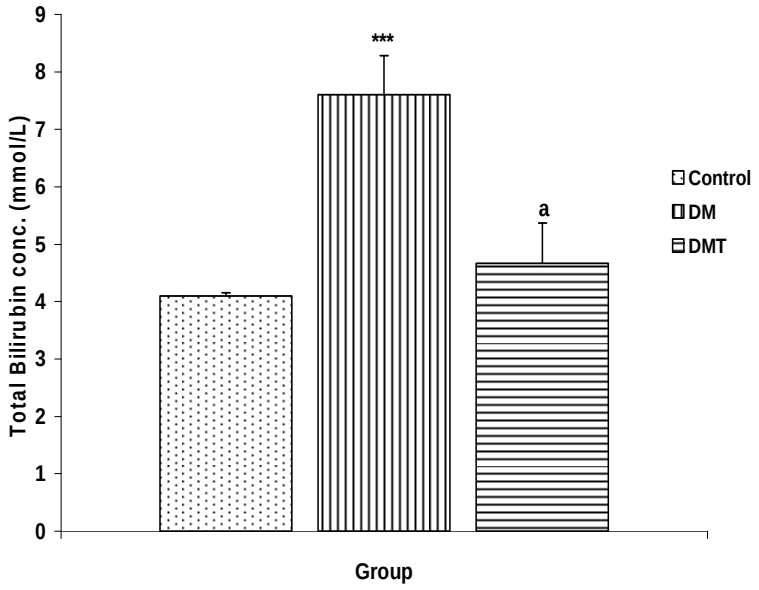

Fig. 1. Comparison of total serum cholesterol (TC) concentration in the different experimental groups

*Test drugs: significant from normal control, a =P < 0.05 vs DM; *** =P < 0.001vs Control*
Mean ± S.E.M = Mean values ± Standard error of means of six experiments

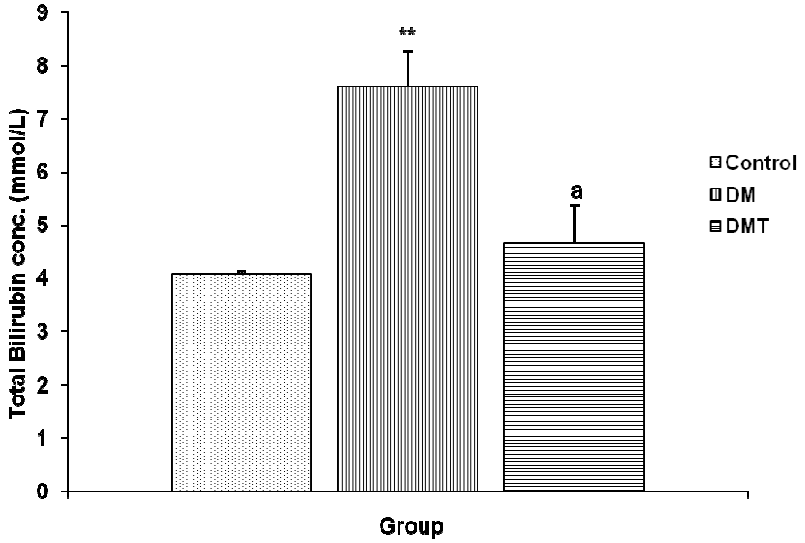

Fig. 2. Comparison of total serum bilirubin concentration in the different experimental groups.

*Test drugs: significant from normal control, a =P < 0.05 vs DM; *** =P < 0.001vs Control*
Mean ± S.E.M = Mean values ± Standard error of means of six experiments

3.1.3 Estimated serum conjugated bilirubin levels in the control, DM and DMT experimental groups of rats

The mean values of serum conjugated bilirubin were: 2.3 ± 0.44, 3.3 ± 0.25 and 2.6 ± 0.53mmol/L for control, DM and DMT respectively. The DM group was significantly higher (P=.01) than the control, Fig. 3.

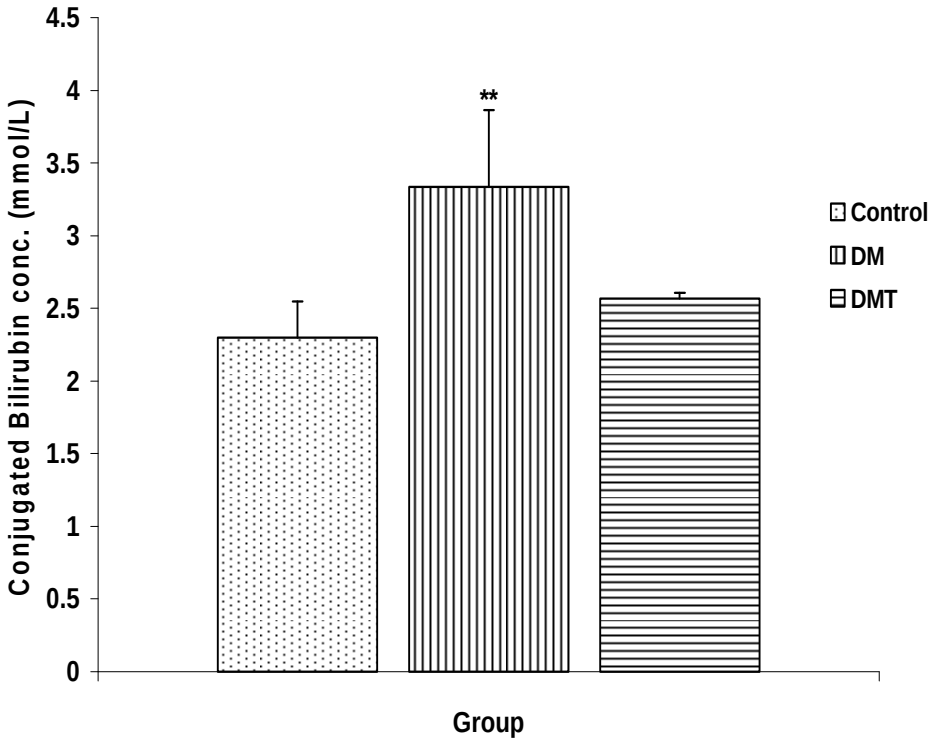

Fig. 3. Comparison of serum conjugated bilirubin concentration in the different experimental groups

*Test drugs: significant from normal control,** =P < 0.01 vs. Control*
Mean ± S.E.M = Mean values ± Standard error of means of six experiments
***P=.01 vs control.*

3.2 Serum Electrolytes in the Various Experimental Groups of Rats

The electrolytes investigated include: Na^+, K^+, Cl^-, and HCO_3-.

3.2.1 Serum sodium ion concentration in the control, DM and DMT experimental groups of rats

The mean Na^+ concentrations were 126 ± 0.894, 126 ± 2.632, and 129 ± 0.918mmol/L in the control, DM and DMT groups respectively. The DMT group was significantly (P=.01) higher than the control group. (Fig. 4).

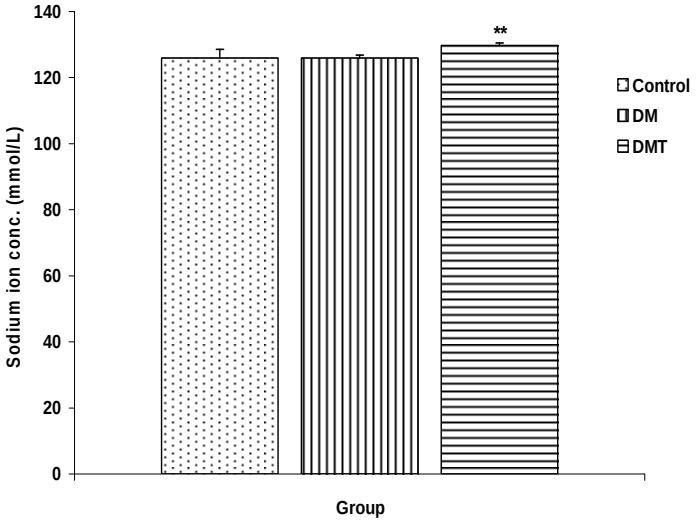

Fig. 4. Comparison of serum sodium ion concentration in the different experimental groups

*Test drugs: significant from normal control, ** P < 0.01*
Mean ± S.E.M = Mean values ± Standard error of means of six experiments

3.2.2 Serum potassium ion concentration in the control, DM and DMT experimental groups of rats

The mean K^+ concentration in the control, DM and DMT groups were: 4.9 ± 0.44, 5.2 ± 0.31, and 4.8 ± 0.26mmol/L respectively. There were no significant differences between the groups, Fig. 5.

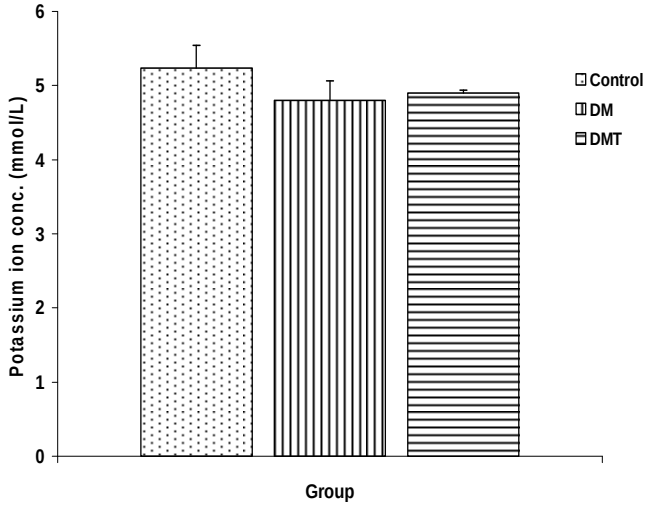

Fig. 5. Comparison of serum potassium ion concentration in the different experimental groups

Mean ± S.E.M = Mean values ± Standard error of means of six experiments

3.2.3 Serum chloride ion concentration in the control, DM and DMT experimental groups of rats

The mean Cl^- concentrations in these groups were: 101 ± 0.45, 94 ± 0.73 and 92 ± 0.84mmol/L respectively. The test groups (DM and DMT) concentrations were significantly (P=.001) lower than the control group, Fig. 6.

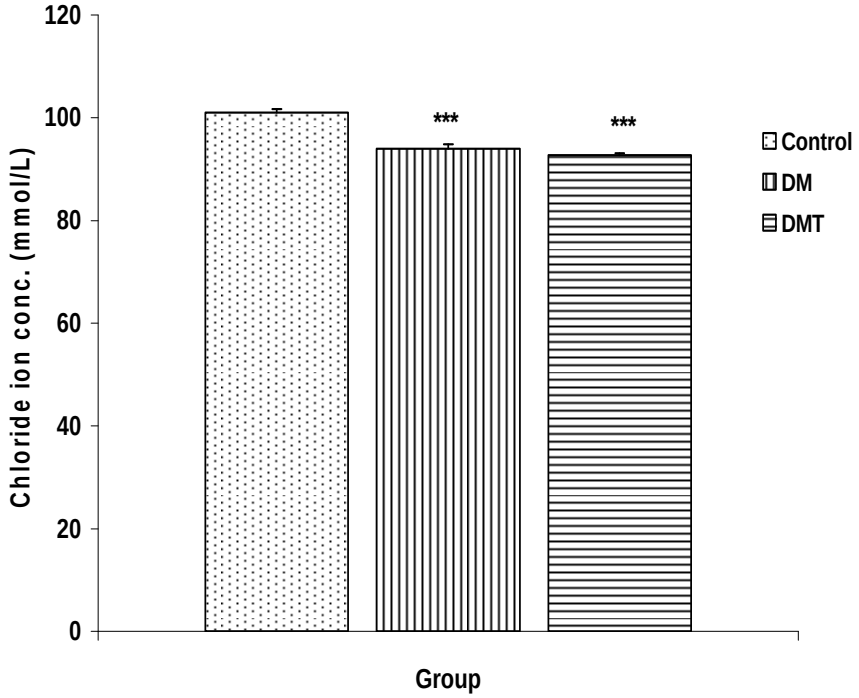

Fig. 6. Comparison of serum chloride ion concentration in the different experimental groups

*Test drugs: significant from normal control ** =P < 0.001vs Control.*
Mean ± S.E.M = Mean values ± Standard error of means of six experiments.

3.2.4 Serum bicarbonate ion concentration in the various experimental groups of rats

The mean HCO_3- concentration in the control, DM and DMT groups were: 19 ± 0.45, 17 ± 0.37, and 19 ± 0.37 respectively. There were significant differences between the groups. The DMT was significantly (P=.01) lower than the control, while the DMT was significantly higher (P =.01) than the DM group, Fig. 7.

3.3 Biliary Cholesterol, Total Bilirubin, Conjugated Bilirubin and Unconjugated Bilirubin in the Different Experimental Groups of Rats

3.3.1 Biliary cholesterol concentration in the different experimental groups of rats

The mean biliary cholesterol concentration in the control, diabetic control and diabetic treated groups were 0.63 + 0.01, 0.95 + 0.10 and 0.89 + 0.01mmol/L respectively. The cholesterol concentration in the diabetic control was significantly higher (P < 0.05) when

compared with the control. However, the cholesterol concentration in the diabetic-treated was significantly higher (P=.001) than in the control, but was also not significantly higher than that in the diabetic control group (Fig. 8).

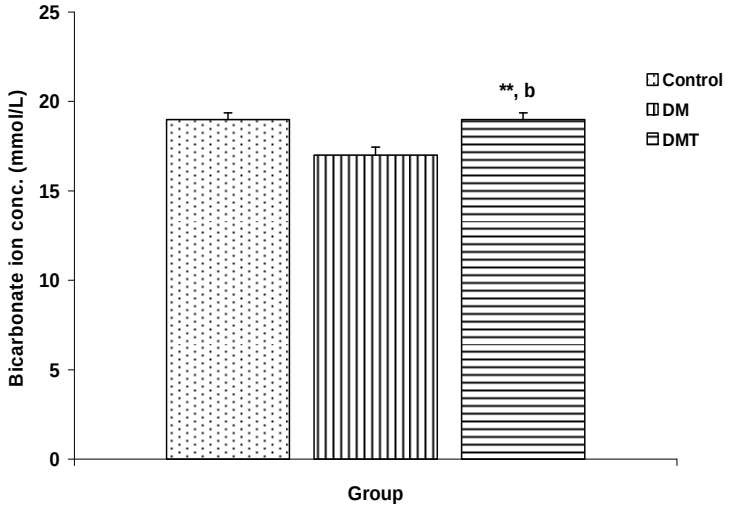

Fig. 7. Comparison of serum bicarbonate ion concentration in the different experimental groups

*Test drugs: significant from normal control, a =P < 0.01 vs DM; *** =P < 0.01vs Control. Mean ± S.E.M = Mean values ± Standard error of means of six experiments.*

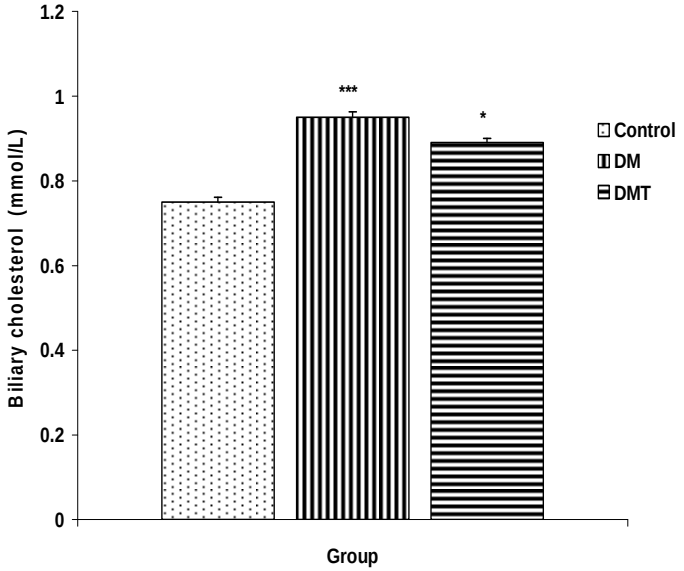

Fig. 8. Comparison of biliary cholesterol concentration in the different experimental groups

*Test drugs: significant from normal control, *=P < 0.05 vs DM; *** =P < 0.001vs Control. Mean ± S.E.M = Mean values ± Standard error of means of six experiments.*

3.3.2 Biliary total bilirubin concentration in the different experimental groups of rats

The mean total biliary bilirubin concentration in the diabetic control (23.23 + 5.11mmmol/L) was significantly higher ($P < 0.05$) when compared with the control group (6.30 + 0.57mmol/L). However, the mean total bilirubin concentration in the diabetic-treated (9.25 + 0.18mmol/L) was significantly higher (P=.001) than that in the control group, but was also significantly lower ($P < 0.05$) when compared with the diabetic control group (Fig. 9).

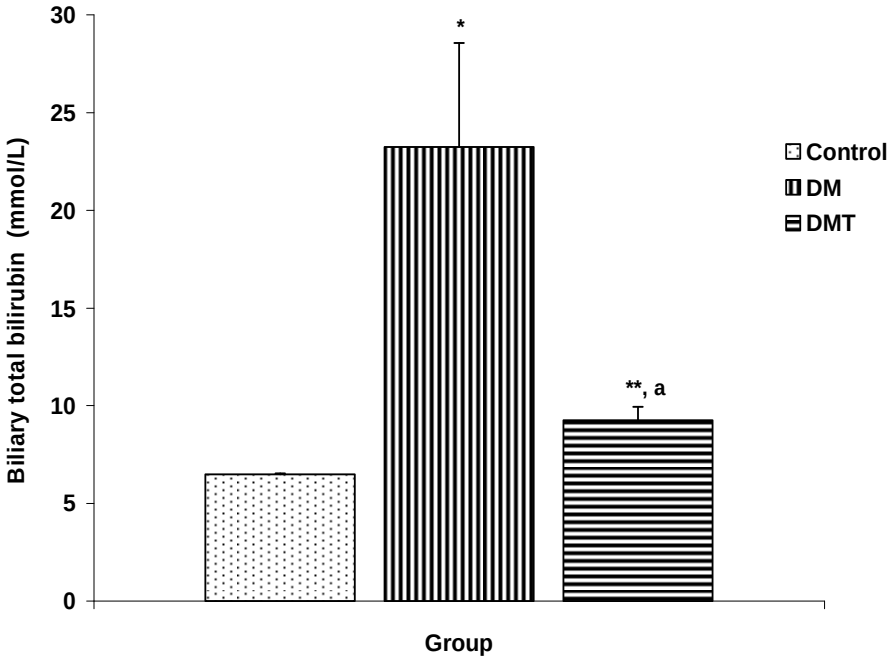

Fig. 9. Comparison of biliary total bilirubin concentration in the different experimental groups

*Test drugs: significant from normal control, *P=.05, a =P < 0.05 vs DM; ** =P < 0.001vs Control*
Mean ± S.E.M = Mean values ± Standard error of means of six experiments

3.3.3 Biliary conjugated bilirubin concentration in the different experimental groups of rats

The mean biliary conjugated bilirubin concentration in the control, diabetic control and diabetic treated were 3.73 + 0.44, 15.53 + 3.08 and 3.33 + 0.45mmol/L respectively. The result showed that the conjugated bilirubin concentration in the diabetic control group was significantly higher (P=.001) when compared with the control group. However, the conjugated bilirubin concentration in the diabetic treated group was significantly lower (P=.001) than that in the diabetic control group (Fig. 10).

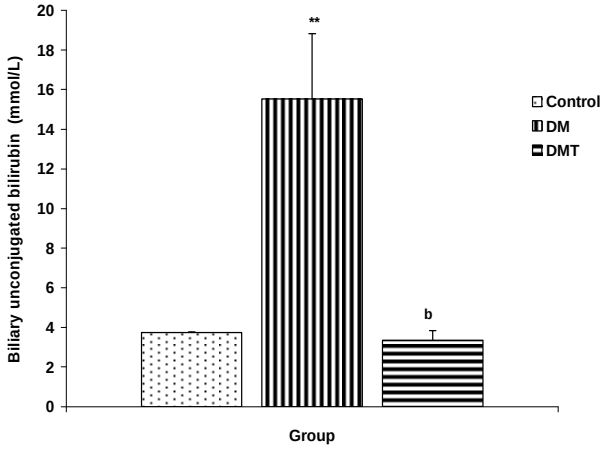

Fig. 10. Comparison of biliary conjugated bilirubin concentration in the different experimental groups

*Test drugs: significant from normal control, b =P < 0.01 vs DM; ** =P < 0.001vs Control. Mean ± S.E.M = Mean values ± Standard error of means of six experiments.*

3.3.4 Biliary unconjugated bilirubin concentration in the different experimental groups of rats

The mean biliary unconjugated bilirubin concentration in the diabetic control group was 7.70 + 2.10mmol/L. This was significantly higher (P=.05) than that in the control group (2.58 + 0.13mmol/L). The mean unconjugated bilirubin concentration in the diabetic treated group (5.93 + 0.50ml/L) was significantly higher (P=.001) than that in the control group. There was no significant difference between the diabetic control and the diabetic treated groups (Fig. 11).

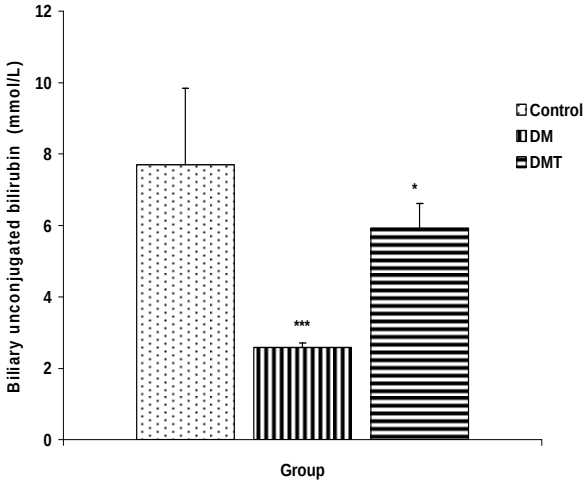

Fig. 11. Comparison of biliary unconjugated bilirubin concentration in the different experimental groups

*Test drugs: significant from normal control, *=P < 0.05 vs DM; *** =P < 0.001vs Control. Mean ± S.E.M = Mean values ± Standard error of means of six experiments.*

3.4 Biliary Electrolytes in the Various Experimental Groups of Razts

3.4.1 Biliary sodium ion (Na^+) concentration in the different experimental groups of rats

The mean Sodium ion (Na^+) Concentration in the control, Diabetic control and Diabetic treated groups were 132.5+ 0.29, 148.0 + 2.58 and 133.5 + 1.44mmol/L respectively. The result shows that Na^+ concentration in the Diabetic control group was significantly higher (P=.001) than in the Control group. The Diabetic treated group, showed a significant decrease (P=.01) in Na^+ concentration when compared with the Diabetic Control Group (Fig. 12).

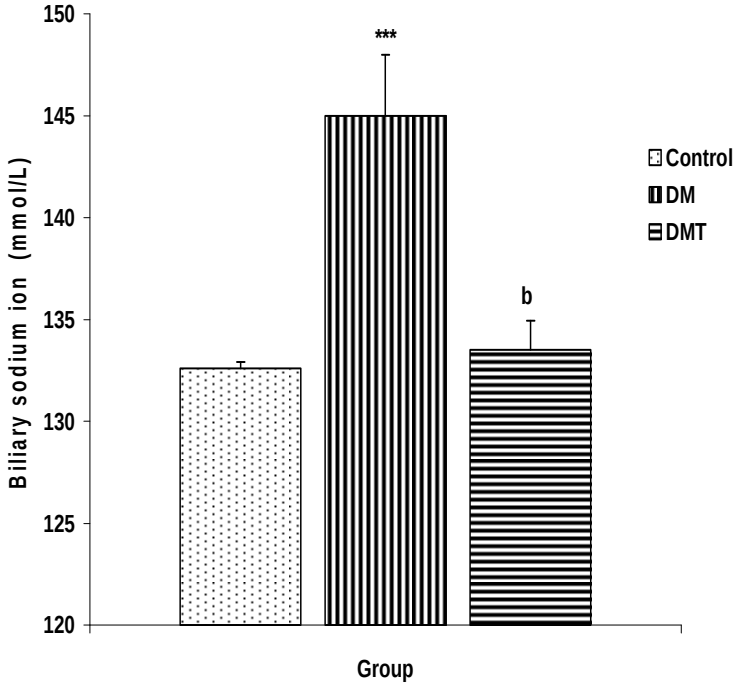

Fig. 12. Comparison of biliary sodium ion levels in the different experimental groups.
*Test drugs: significant from normal control, a =P < 0.01 vs DM; *** =P < 0.001vs Control*
Mean ± S.E.M = Mean values ± Standard error of means of six experiments

3.4.2 Biliary potassium ion (K^+) concentration in the different experimental groups of rats

Bile potassium concentration in diabetic control group (5.25 + 0.29mmol/L) was not significantly different when compared to the control group (4.85 + 0.09mmol/L). However, the K+ concentration in the diabetic treated group (4.05+ 0.10mmol/L) was significantly lower than in the control (P=.001) and diabetic control (P=.001) respectively (Fig. 13).

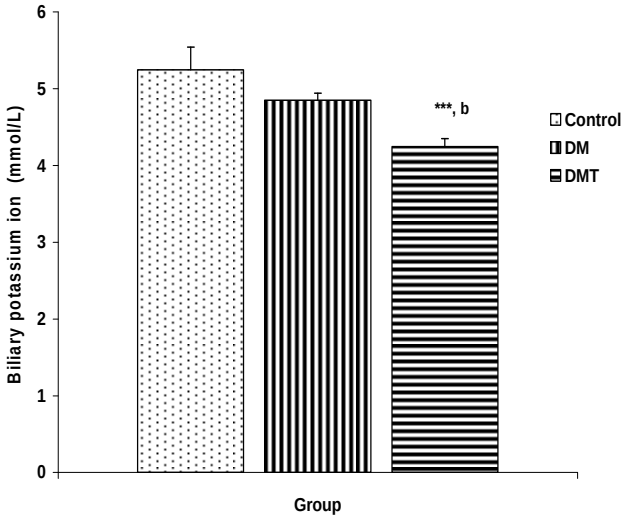

Fig. 13. Comparison of biliary potassium ion levels in the different experimental groups

*Test drugs: significant from normal control, b =P < 0.01 vs DM; *** =P < 0.001vs Control.*
Mean ± S.E.M = Mean values ± Standard error of means of six experiments.

3.4.3 Biliary chloride ion (Cl^-) concentration in the different experimental groups of rats

The mean bile chloride ion concentration in the control, diabetic control and diabetic treated were 92.75 + 0.48, 91.00 + 1.29 and 93.25 + 0.48mmol/L respectively. There was no significant difference amongst the groups (Fig. 14).

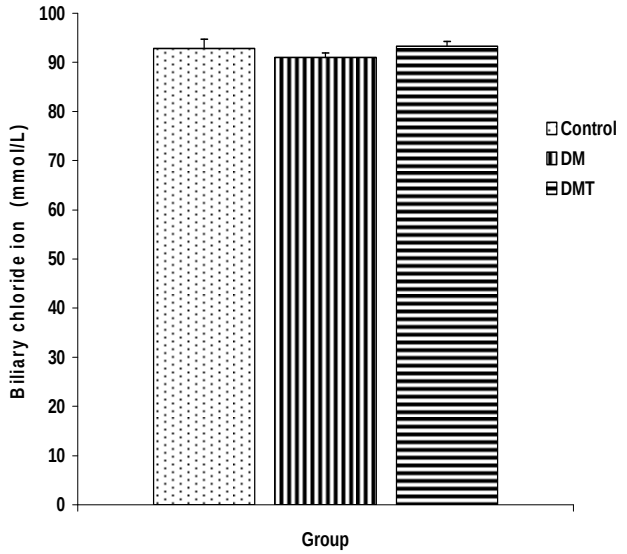

Fig. 14 Comparison of biliary chloride ion levels in the different experimental groups.

Mean ± S.E.M = Mean values ± Standard error of means of six experiments

3.4.4 Biliary bicarbonate (HCO_3^-) ion concentration in the different groups of rats

The mean bile bicarbonate ion (HCO_3^-) concentration in the diabetic control group (33.75 + 1.03mmol/L) and diabetic-treated group (32.25 + 0.48mmol/L) were significantly higher (P=.001) when compared with that in the control group (29.25 + 0.48mmol/L). There was no significant difference in HCO3- concentration in diabetic-treated group when compared with the diabetic control group (Fig. 15).

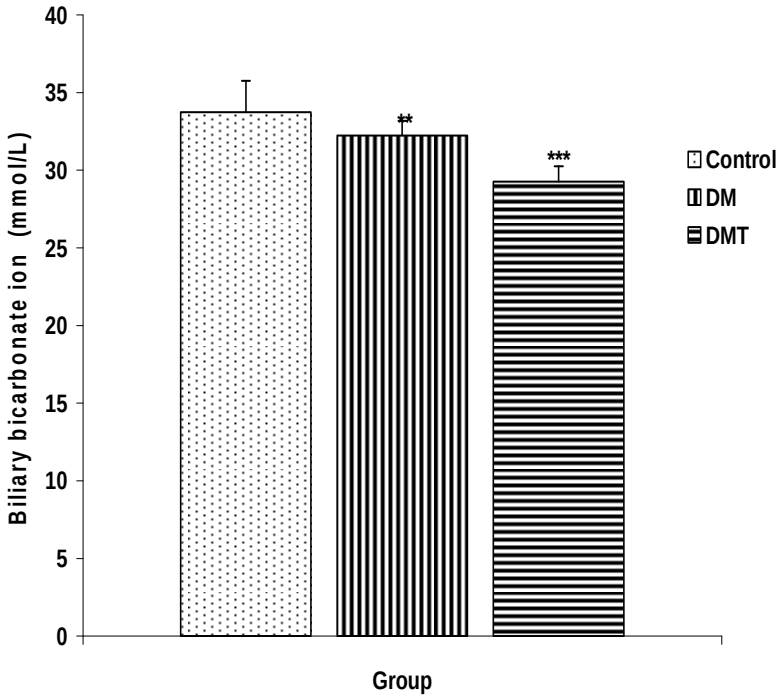

Fig. 15. Comparison of biliary bicarbonate ion levels in the different experimental groups

*Test drugs: significant from normal control, *** =P < 0.001 vs DMT; *** =P < 0.01vs Control. Mean ± S.E.M = Mean values ± Standard error of means of six experiments.*

3.5 Serum and Biliary Bilirubin, Cholesterol and Electrolytes

Total conjugated and unconjugated bilirubin in the serum and bile were raised in the DM and DMT test groups compared to the control group. There was a significant reduction of this level in the DMT group when compared to the DM group. This connotes that Ocimum gratissimum (OG) reduces bilirubin levels raised in Type 1 DM. The pattern of increment in the various forms of bilirubin estimated in this study were similar in both serum and bile; pointing to the possibility of extrahepatic involvement in the pathologic process involved in the rise. Hyperbilirubinaemia without any abnormality of other liver function tests may result from increased bilirubin production, as in haemolysis or ineffective erythropoiesis, or from inability to transport bilirubin across the liver as in Gilbert's syndrome [24].

Irrespective of the pathologic site resulting in the bilirubin levels increase in DM, this research has demonstrated the fact that Ocimum gratissimum tends to reverse the

abnormality as seen in the significant reduction of the bilirubin levels in the DMT group. This is also an indicator that Ocimum gratissimum may possess some hepato-protective properties.

Serum and biliary cholesterol levels showed a related increase in the DM and DMT groups, when compared with the control group. The cholesterol estimate in both serum and bile were lower in the DMT group compared to the DM group. It is reported that diabetics have abnormal serum lipid profiles and increased biliary cholesterol secretion, resulting in increased cholesterol saturation of bile [1,2]. It therefore appears from the result of this study that Ocimum gratissimum treatment improves the abnormal serum lipid profiles, thus leading to reduction in both serum and biliary cholesterol levels. It is possible that this may be related to the enhanced pancreatic exocrine activity of Ocimum gratissimum which increased pancreatic amylase and lipase secretion.

Serum electrolytes levels were predominantly decreased except for sodium (Na^+) in the test groups compared to the control. While all the levels of bile electrolytes (Na^+, K^+, Cl^-, HCO_3^-) estimated in this study were generally increased in the test groups when compared to the control group.

The kidney plays a crucial role in electrolyte regulation. Between the test groups, serum electrolytes level were higher (near normal) in the DMT group than DM group except chloride ion. Also bile electrolytes levels were lower in the DMT group than DM group except potassium ion. There were no significant changes in the bile chloride ion levels for control and test groups. Shahid and Mahaboo [25] had reported the progressive trends in electrolyte abnormalities in DM leading to end stage renal disease along with the abnormality of their chief transport mechanism.

There is increasing evidence that Reactive Oxygen Species (ROS) play a major role in the development of diabetic complications. Ha et al. [26] had reported that oxidative stress is increased in DM, and the over production of ROS in DM is a direct consequence of hyperglycemia. He also noted that various types of vascular cells including renal cells are able to produce ROS under hyperglycemic condition. Both NADPH oxidase and mitochondrial electron gradient play roles in hyperglycemia-induced ROS generation [26]. In addition to their ability to directly inflict macromolecular damage, ROS can function as signaling molecules to mediate hyperglycemia-induced activation of signal transduction of profibrotic genes in the kidney leading to renal disease [26]. The resulting renal disease may affect electrolyte handling! Conventional and catalytic antioxidants have been shown to prevent or delay the onset of diabetic nephropathy, by opposing the activity of ROS [26]. The fact that the serum electrolyte levels in the DMT group were closer to the control suggests that Ocimum gratissimum may possess antioxidant agent capable of abolishing or delaying the activity of ROS. Thus, ameliorating the diabetic nephropathy and enhances renal functions including electrolyte regulation.

Insulin deficiency causes drift of K^+ ion out of cells leading to hyperkalemia [27]. The significant increase in K^+ concentration in bile in the DMT group of experimental rats compared to the control and DM group supports the hypothesis that the hypoglycemic effect of Ocimum gratissimum may not be related to increase insulin secretion from the pancreatic islets. The overall rise in bile electrolyte concentration compared to serum electrolytes further buttresses the cholagogue action of Ocimum gratissimum. It is known that glycosuria (a cardinal feature of DM) causes dehydration via glucose osmotic diuresis. This dehydration is accompanied with severe loss of electrolyte including Na^+, K^+, Ca_2^+, Cl^- and PO_4- [28,29].

This study also collaborate these previous reports, with a markedly reduced serum electrolytes levels in the DM and DMT groups.

4. CONCLUSION

The hypoglycemic property of Ocimum gratissimum reported in previous studies was collaborated to be true from our result. STZ-induced type I DM was found to be associated with derangement in biliary and serum bilirubin, cholesterol and electrolytes, indicative of a likely hepatic and renal impairment. Treatment with Ocimum gratissimum was found to obviate these derangements in biliary and serum bilirubin, cholesterol and electrolytes. This is suggestive of a possible hepatoprotective and nephroprotective properties of Ocimum gratissimum.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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