Innovations

Changes in Serum Cardiac Biomarkers Levels of Different Extracts of Terminalia Catappa and Aspirin in Diabetic Rats

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Abstract

Background: *Myocardial abnormalities silently exist in diabetes mellitus and assessment of some cardiac bio markers are used to achieve early diagnosis and management.* ***Aim:*** *To investigates changes in cardiac biomarkers in diabetic rats treated with different extracts of Terminalia catappa leaves.* ***Method****: A total of Fifty-four (54) male Wistar rats were randomly shared into 8 groups of 6 rats per group. Group 1 (control) received 5ml/kg body weight of distilled water orally. Group 2 was treated with aqueous leaf extract of T. catappa at 130mg/Kg body weight orally while Group 3, diabetic untreated group orally received distilled water, 5ml/Kg body weight. Groups 4 and 5 were diabetic rats treated respectively with 130mg/Kg body weight of aqueous leaf extract of T. catappa and subcutaneous administration of insulin, 0.75U/Kg body weight. Group 6 received methanol extract of T. catappa leaf extract; 130mg/Kg body weight, group 7 received ethanol extract of T. catappa leaf extract; 130mg/Kg body weight and group 8 was administered orally with 30 mg/Kg body weight of aspirin. Diabetes was induced with streptozotocin; 65 mg/Kg body weight.* ***Results:*** *Increase in CKMB was significant ($p < 0.05$) while the increase in Troponin, LDH and BNP were marginal in diabetic untreated group. A significant reduction was observed in CKMB and LDH in aqueous extract treated but significant increase in serum levels of Troponin, CKMB, LDH and BNP in ethanol extract, methanol extract and aspirin treated groups.* ***Conclusion:*** *Aqueous extract of T. catappa reduces cardiac biomarkers to ameliorates myocardial injury while ethanol and methanol extracts cause cardio-toxicity in diabetic rats.*

Key words: *cardiac biomarkers, Terminalia catappa, insulin, myocardial infarction, diabetes mellitus.*

1. Introduction

Diabetes mellitus (DM) constitutes serious cardiovascular risks with attendant high morbidity and mortality in diabetic population (Jyotsna et al, 2023, Santulli et al, 2015). DM induced cardiovascular complications have been established (Jyotsna et al, 2023, Rawshani et al,

2018; Forbes and Cooper, 2013). Such cardiovascular complications include nephropathy, retinopathy and neuropathy, peripheral artery disease (PAD), cerebrovascular disease and ischemic heart disease (IHD) (Chatterjee et al, 2018; Santulli et al, 2015). A major clinical condition associated with diabetic induced cardiac abnormalities is cardiomyopathy (Sardu et al, 2019). Diabetic cardiomyopathy (DCM) is characterised with cardiac hypertrophy, apoptosis, inflammation and oxidative stress (Bugger and Bode 2015; Trachanas et al, 2014). However, many diabetic patients develop silent cardiac abnormalities which are asymptomatic (Distiller, 2014). It is commonly observed that diagnosis and subsequent attention on these complications occur at the later stages of the disorders (Chatterjee et al, 2018). The early part of cardiac abnormalities may begin as simple necrosis which may not be easily detected. This necrosis progresses gradually following development of metabolic disorder, ventricular hyperplasia, and abnormalities of extracellular matrix and coronary microvascular disease (Picatoste et al, 2013). It is established that inflammation and reactive oxygen species production increases due to Hyperglycemia in diabetes mellitus (Falcão-Pires and Leite-Moreira, 2012; Picatoste et al, 2013) and these can result in cardiac muscle apoptosis (Huang et al, 2015; Mohamed et al, 2015). Every diabetic patient is thus considered to have developed inherent cardiovascular risk and early diagnosis is key to reducing the progression and mortality associated to the cardiac abnormalities (Bamba, 2014). Therefore, various biomarkers are used in the diagnosis of myocardial abnormalities. Such biomarkers are troponin, brain natriuretic peptide and creatinine kinase-MB. Some liver enzymes such as ALT, AST and LDH are also useful markers (Bhattacharya et al, 2013; Szunerits et al, 2019; Agarkov et al, 2020). In the treatment of cardiac abnormalities, tight glycemic control is the main therapeutic approach using insulin, oral hypoglycemic agents, beta-blockers, angiotensin receptor blockers (Borghetti et al, 2018; Ge et al, 2019). Other modern therapy involves use of glucacon-like receptor agonist but the cardiovascular safety is yet to be fully established (Nicholis et al, 2024). In both mono- or combination therapy, use of these regimens have some challenges in achieving expected success rate and are associated with varieties of side effects (Ge et al, 2019). These challenges possess limitations to effective use of this regimens in clinical practice for myocardial abnormalities in diabetes mellitus. Severe complications associated with conventional medications has necessitate the use of medicinal plant or isolated phytoconstituents either as mono- or combination therapy to provide alternatives efficacious treatment of myocardial abnormalities in diabetes mellitus (Lingmei et al, 2024; Noushida et al, 2024). Terminalia catappa has been found in our previous study to possess antidiabetic (Ben et al, 2019a), anti-inflammatory and anti-oxidative properties (Ben et al, 2019b). In the light of established mechanism of diabetic cardiomyopathy which involves inflammation and oxidative stress, this study therefore seeks to investigate the effect of aqueous, methanol and ethanol leaf extracts of T. catappa on cardiac biomarkers in diabetic rats.

2. Materials and Methods

2.1. Extract Preparations

Aqueous, methanol and ethanol extracts were prepared using fresh leaves of Terminalia catappa plucked from Almond Tree at University of Uyo premises. The leaves were presented for authentication by a botanist and registered in Botany and Ecological Studies Department, University of Uyo and habarium number was UUPH/22(a). The leaves were washed and air-dried overnight at room temperature and pulverized. To obtain aqueous extract, 5000g of the pulverized leaves was soaked in 5 litres of deionised water for 18 hours, filtered with muslin cloth and evaporated to dryness in a thermostatic water bath at 45°C until a semi solid paste of the extract weighing 204.18g was obtained representing 4.08% percentage yield and was stored in a refrigerator for use during the experiment. Methanol and ethanol leaf extracts were obtained by macerating 1000g of pulverized leaves in 80 (v/v) methanol and ethanol respectively and were

evaporated at 45°C to obtain a pastes. The pastes were stored in refrigerator for use during the experiments.

2.2. Experimental Animal

Male rats of Wister strain weighing on the average, 150 grams were procured for the study from Faculty of Basic Medical Science Animal Unit, University of Uyo. The animals were allowed to acclimatized for two weeks before commencement of experiment and were allowed free access to feed (Guinea Feeds, Plc Nigeria) and water.

2.3. Induction of diabetes mellitus

Diabetes induction was through the use of streptozotocin (STZ) from Sigma-Aldrich according to methods of Lenzen (2017) and Furman (2021). Streptozotocin (STZ) was dissolved in citrate buffer (citric acid and sodium citrate, enzyme grade from Fisher) with pH 4.5 prepared just before administration. The STZ was administered by intraperitoneal injection, 65 mg/Kg body weight (Donovan and Brown, 2006a). The animals were provided with 10% (w/v) sucrose (from Sigma) water for the first 24 hours to avoid severe hypoglycaemia. Feed was withdrawn on previous night for measurement of fasting blood glucose and the animals were fasted for about 12 hours (Furman, 2021). Development of diabetes was determined after 48 hours of STZ administration by obtaining blood sample from the tip of the tail. Using One Touch glucometer (One Touch Ultra, Life Scan Inc, U.S.A) blood glucose was measured and blood glucose ≥200 mg/dL was considered diabetic (normal range of blood glucose in rat is 80 – 120 mg/dL) and were used for the experiment which lasted for 14 days.

2.4. Experimental Design

The experiment was designed by random distribution of Wistar rats into eight groups consisting of six rats in each group as shown below;

Table 2.1 The design of the experiment

Group	Group Name	Number	Substance/dosage	Route
Group 1	Control	6	Distilled water 5mL/Kg BW	Orally
Group 2	Control + Aqueous Extract	6	Aqueous extract 130 mg/Kg BW	Orally
Group 3	Diabetic	6	Distilled water 5ml/Kg BW	Orally
Group 4	Diabetic + Aqueous Extract	6	Aqueous extract 130 mg/Kg BW	Orally
Group 5	Diabetic + Insulin	6	Insulin 0.75UI/Kg BW	Subcuta-neously
Group 6	Diabetic + Methanol Extract	6	Methanol extract 130 mg/Kg BW	Orally
Group 7	Diabetic + Ethanol Extract	6	Ethanol extract 130 mg/Kg BW	Orally
Group 8	Diabetic + Aspirin	6	Aspirin 30 mg/Kg BW	Orally

2.5. Assessment of cardiac biomarkers and insulin

The cardiac biomarkers; Troponin, creatine kinase muscle/brain, brain natriuretic peptide, lactate dehydrogenase enzymes and insulin were assessed from the serum using ELISA method. The commercial analysis kits were used with procedures according to manufacturer's guides (Shabab et al, 2024).

2.6. Ethical Approval

Approval was obtained for the experimental protocol from Faculty of Basic Medical Science Animal Research Ethics Committee (FAREC-FBMS) with approval number of 021PY30417.

2.7. Statistical analysis

The statistical analysis was carried out with GraphPad Prism 5.0 statistical software. One-way analysis of variance (ANOVA) was use for comparison of the mean and post hoc Turkey test was carried out among the groups. The result is presented as mean ±standard error of mean (SEM) and $p<0.05$ is considered significant.

3. Results

3.1. Serum Troponin level

Serum troponin level (figure 1) was 43.67±1.12 pg/mL in the control group, 43.67±0.56 pg/mL in control+extract group and the diabetic group was 47.00±0.37 pg/mL. Slight increase was observed in diabetic group but this was not significant compared with control group. There was also a slight decrease in troponin level in the diabetic+extract group to 45.00±0.73 pg/mL compared with the diabetic untreated group but this value was still higher than the control group value. In diabetic insulin treated group, there was a marginal reduction to mean value of 40.00±0.1 pg/mL when compared with both diabetic untreated group and control group. In the diabetic+methanol extract, diabetic+ethanol extract and diabetic+aspirin treated groups, the values were significantly ($p<0.05$) raised respectively to 80.67±4.04 pg/mL, 73.00±5.84 pg/mL and 68.00±05.04 pg/mL when compared with control and diabetic group, diabetic+extract and diabetic+insulin group.

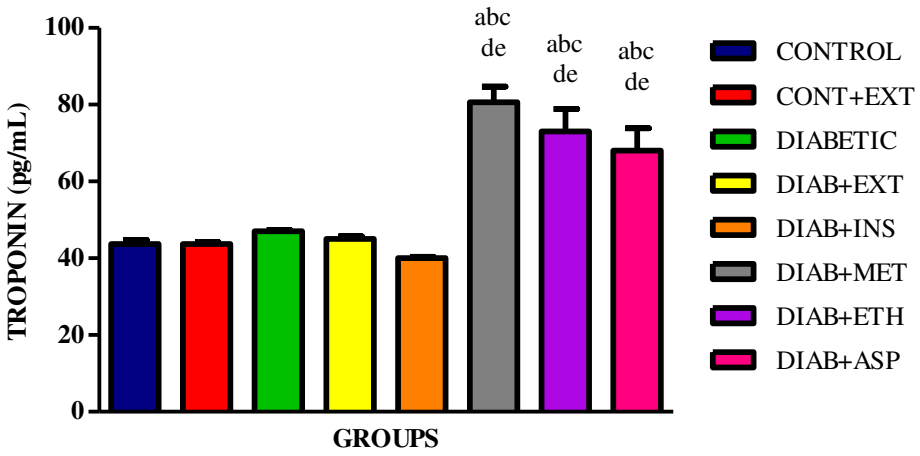

Fig. 1. Serum Troponine levels in control and experimental groups. Values are in mean ± SEM, $p<0.05$. a= test vs control, b= test vs control+extract, c= test vs diabetic group.

3.2. Creatine kinase MB (CKMB) Level

The results of Creatine kinase-MB (CKMB) (in figure 2) was 22.00±0.82 IU/L in the control group, control+extract group was 23.23±0.53 IU/L while diabetic group was 28.13±0.75 IU/L. The CKMB of the diabetic group was significantly ($p<0.05$) higher than both control and control+extract groups. The diabetic group treated with T. catappa aqueous leaf extract showed significant ($p<0.05$) reduction to a mean values of 23.30±0.74 IU/L when compared with diabetic group and 24.67±0.43 IU/L in diabetic+insulin which was not significantly different from the control and

diabetic groups values. In diabetic group treated with methanol and ethanol extracts, the values were 39.80±1.02 IU/L and 40.43±0.15 IU/L while the aspirin treated diabetic group had 32.57±2.14 IU/L and all these were significantly ((p<0.05) higher than the control group, diabetic group and diabetic insulin treated group

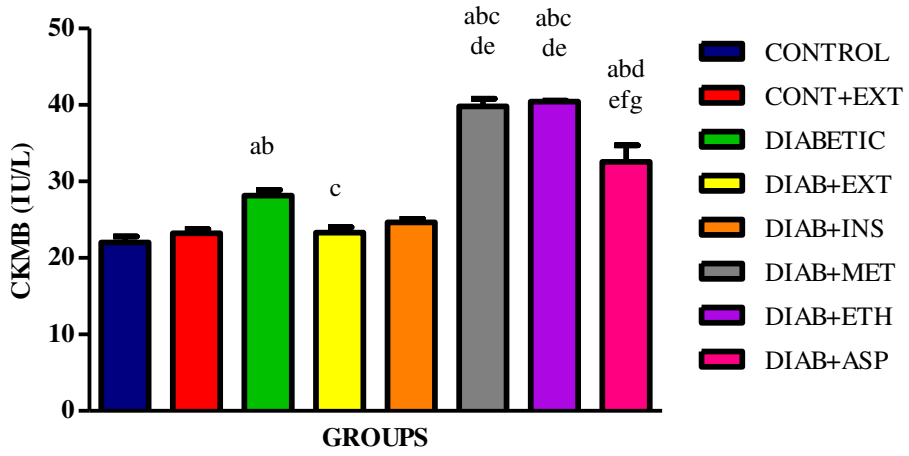

Fig. 2. Serum creatine kinase muscle/brain levels in control and experimental groups. Values are in mean ± SEM, p<0.05. a= test vs control, b= test vs control+extract, c= test vs diabetic group, d= test vs diabetic+extract, e= test vs diabetic+insulin, f= test vs diabetic+methanol extract.

3.3. Brain Natriuretic peptide (BNP) Level

In figure 3, the results of brain natriuretic peptide BNP are represented. The serum levels of BNP for control, control+extract and diabetic groups were 89.00±2.19 pg/mL, 86.33±2.20 pg/mL and 95.33±0.92 pg/mL respectively. The results of BNP of diabetic untreated group was slightly higher than the control group and control+extract group values. BNP in diabetic group treated with aqueous extract reduced marginally to 86.00±1.32 pg/mL and insulin treated group was 81.67±6.08 pg/mL which also not significant compared to control and diabetic groups. Methanol extract treated group had increased BNP of 128.3±2.38 pg/mL which was significantly higher than diabetic and control groups. Also the BNP values in diabetic+ethanol extract and diabetic+aspirin treated groups were 128.7±4.98 pg/mL and 132.0±5.67 pg/mL respectively and were significantly higher compared with control and diabetic groups.

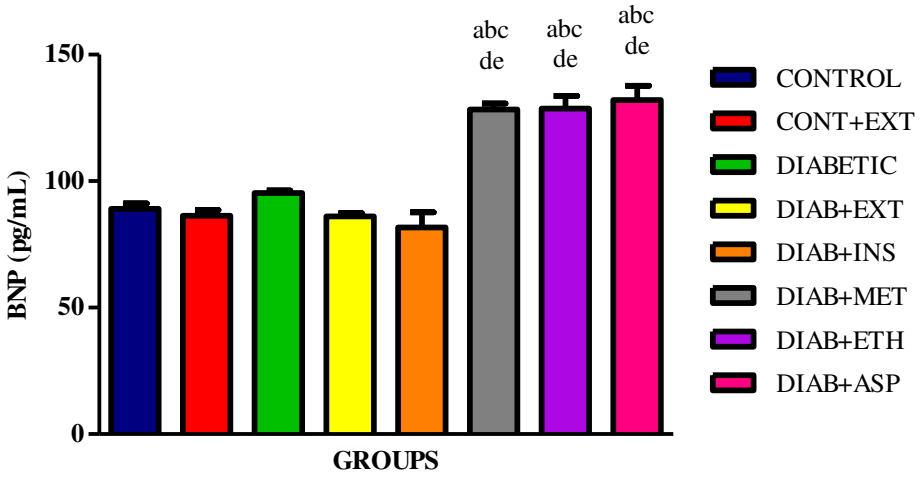

Fig. 3. Serum brain natriuretic peptide levels in control and experimental groups. Values are in mean ± SEM, p<0.05. a= test vs control, c= test vs diabetic group.

3.4. Lactate dehydrogenase (LDH) Level

The results of lactate dehydrogenase level as shown in figure 4 was 22.83±0.79 IU/L, 21.20±1.53 IU/L and 25.20±0.29 IU/L in the control, control+extract and diabetic group respectively. In diabetic group treated with aqueous extract, the value significantly (p<0.05) reduced to 18.07±0.26 IU/L compared to the control and diabetic groups. Diabetic+insulin group also showed significant (p<0.05) reduction to 20.97±0.49 IU/L when compared to diabetic group but not control group. The methanol and ethanol extract treated group values were 19.90±0.42 IU/L and 18.43±0.94 IU/L respectively and were significantly (p<0.05) lower than control and diabetic groups while the aspirin treated diabetic group has 19.27±0. IU/L and was significantly (p<0.05) lower than control and diabetic group.

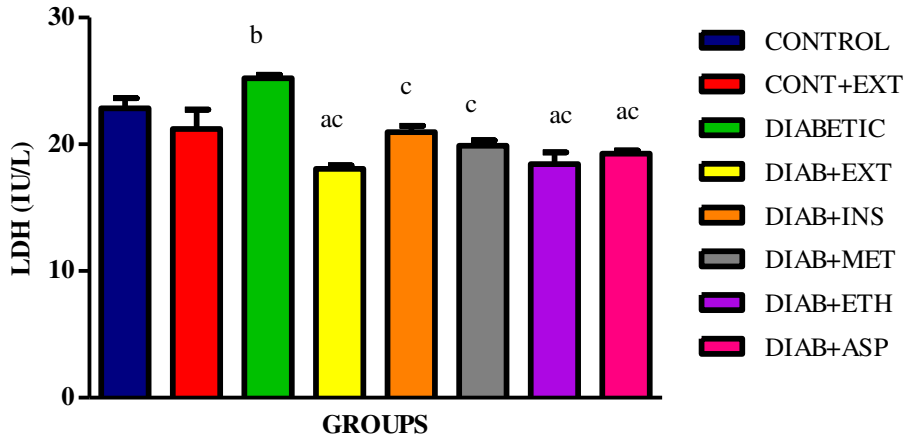

Fig. 4. Serum Lactate Dehydrogenase levels in control and experimental groups. Values are in mean ± SEM, p<0.05. a= test vs control, b= test vs control+extract, c= test vs diabetic group, d= test vs diabetic+extract, f= test vs diabetic+methanol extract.

3.5. Aspartate Aminotransferase (AST) Level

The results of aspartate are represented in figure 5. The serum level of aspartate was 15.00±0. IU/L in the control group, 10.00±0.37 IU/L in control+extract group and 9.33±0.56 IU/L in diabetic

group. The diabetic+extract and diabetic+insulin groups showed significant ($p<0.05$) reductions to mean values of 6.67±0.21 IU/L and 7.00±0.37 IU/L respectively compared to control and diabetic groups. Diabetic group treated with methanol extract had AST value of 5.00±0.37 IU/L significantly ($p<0.05$) reduced compared with both control and diabetic groups. The diabetic groups respectively treated with ethanol extract and aspirin on the other hand showed a significant ($p<0.05$) decrease to a mean values of 7.00±0.37 IU/L and 7.67±0.56 IU/L which were lower significantly ($P<0.05$) than both control and diabetic group.

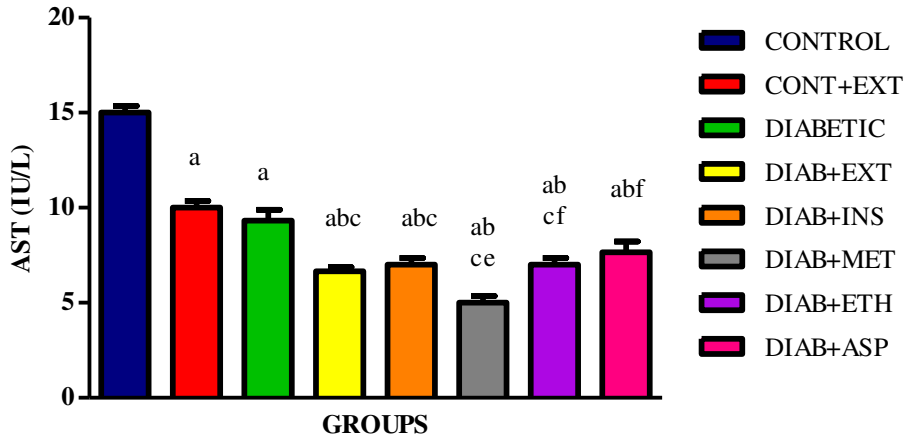

Fig. 5. Serum Aspartate aminotransferase levels in control and experimental groups. Values are in mean ± SEM, $p<0.05$. a= test vs control, b= test vs control+extract, c= test vs diabetic group, d= test vs diabetic+extract, e= test vs diabetic+insulin, f= test vs diabetic+methanol extract.

3.6. Alanine Aminotransferase (ALT)

In figure 6, result of the alanine transferase showed that control group had 8.63±0.26 IU/L, control+extract group had 6.80±0.07 IU/L and diabetic group had 7.43±0.35 IU/L. In the diabetic treated groups; aqueous extract group had 5.73±0.61 IU/L, insulin group was 4.37±0.11 IU/L, methanol extract group was 5.60±0.15, ethanol extract group was 4.93±0.12 IU/L and aspirin treated group was 7.73±1.08 IU/L. Diabetic group value was not up control group but similar to aspirin group. Aqueous and methanol extract treated groups were significantly ($p<0.05$) lower than the control group but insulin and methanol extract treated groups were significantly lower than diabetic group.

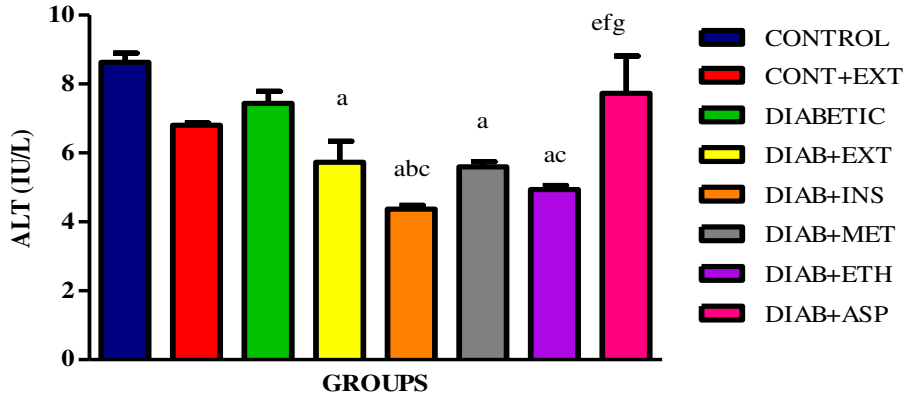

Fig. 6. Serum Alanine aminotransferase level in control and experimental groups. Values are in mean ± SEM, $p<0.05$. a= test vs control, b= test vs control+extract, c= test vs diabetic group, d= test vs diabetic+extract, e= test vs diabetic+insulin, f= test vs diabetic+methanol extract.

3.7. Insulin level

In figure 7, the insulin level for control and control+Aqextract were 0.44±0.07 IU/L and 0.33±0.05 IU/L respectively. These two were not significantly different from each other. In the diabetic group, the value was decreased significantly ($p<0.05$) to 0.24±0.01 IU/L but raised in diabetic aqueous extract group to 0.55±0.10 IU/L and insulin group to 0.45±0.07 IU/L, while 0.44±0.01 IU/L, 0.26±0.03 IU/L and 0.64±0.11 IU/L were obtained in methanol extract, ethanol extract and aspirin treated groups respectively.

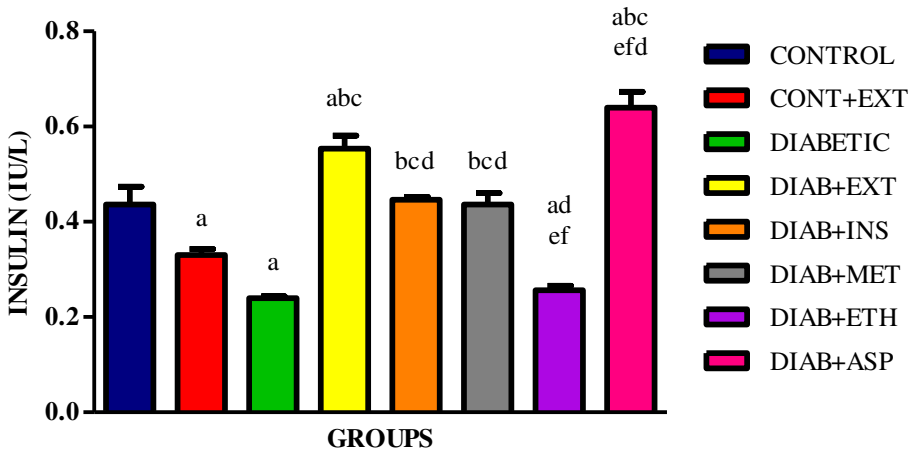

Fig. 7. Serum Insulin levels in control and experimental groups. Values are in mean ± SEM, $p<0.05$. a= test vs control, b= test vs control+extract, c= test vs diabetic group, d= test vs diabetic+extract, e= test vs diabetic+insulin, f= test vs diabetic+methanol extract.

4. Discussion

Cardiac abnormalities can be assessed through the analysis of cardiac biomarkers which are useful parameters for diagnosis of heart status in disease and non-disease conditions. This study was to investigate the changes in cardiac biomarkers in diabetic rats treated with aqueous, methanol, ethanol extracts of Terminalia catappa leaves and aspirin. The biomarkers assessed were troponin level (cTn), creatine kinase (CK-MB), brain natriuretic peptide (BNP) and lactate dehydrogenase (LDH) enzyme. These markers were observed to increase in diabetic group. The increase in Troponin, BNP and LDH were marginal while increase in CK-MB was significant compared with the control group. The result of CK-MB is consistent with other researchers (Mahmud et al, 2020; Yan et al, 2020; Hesham et al, 2012)). Creatine kinase-MB isoenzyme is a specific heart biomarker for diagnosis of myocardial damage (Awais et al, 2016). CK-MB activity is considered a better predictor of heart-muscle damage and an indispensable parameter in the diagnosis of acute myocardial infarction (AMI) (Tiwari et al, 2012). The increased level of creatine kinase-MB may be attributed to hyperglycaemia since elevation of serum levels of CKMB is reported to be more in diabetic patients with myocardial infarction (MI) than non-dibetics with MI (Hesham et al, 2012)). According to Alpert et al (2000), creatine kinase-MB is an important indicator of myocardial necrosis. Thus it could be speculated that the observed increase in the isoenzyme denotes presence of myocardial necrosis in this study.

Although other biomarkers were not significantly increased, it is noteworthy that troponin is a major regulatory protein with high sensitivity to cardiac health status and an indicator of cardiac injury (Serge et al, 2015; Apple et al, 2012; Everett et al, 2011). Therefore, the observed

slight increase might be due to early stage commencement of cardiac muscle injury or abnormalities in myocardial contractility. Again, increased serum level of LDH reflects cardiac damage associated with energy metabolism and is equally used to diagnose acute myocardial infarction (Jain et al, 2023), valve heart disease, heart failure, and coronary heart disease (Piper et al, 2002, Wu et al, 2021). LDH as important intracellular enzyme in energy production catalyses pyruvate to lactate under anaerobic conditions in ischemic tissues (Cobben et al, 1997). Report has shown that LDH elevation can be induced by apoptosis and hypoxia in cardiomyocytes (Cobben et al, 1997; Colgan et al, 2007) and it is also an inflammatory indicator (Faruqi et al, 2012). Therefore, the observed changes in all this cardiac biomarker indicates the state of myocardial abnormalities possibly attributed to the induced diabetic condition. The potency of Terminalia catappa leaves extract is observed in the reduction of CK-MB, Troponin and LDH in the aqueous extract treated group which ameliorates hyperglycemia-induced cardiac abnormalities.

Other cardiac biomarkers investigated were Brain natriuretic peptide (BNP), aspartate aminotransferase (AST), and alanine aminotransferase (ALT). BNP is a biomarker specifically secreted by heart muscle and reported to increase in heart failure and myocardial infarction (Staudt et al, 2006; El-Gohary and Allam, 2016)). The serum BNP level in diabetic untreated group increased slightly and increased BNP is associated with heart failure (Phelan et al, 2012). Sub-threshold elevation of BNP in asymptomatic hypertensive represents subclinical inflammation, cardiac remodelling and extracellular matrix alteration (Phelan et al, 2012). Although the reduction in BNP value in aqueous extract treated group was marginal, attenuation of early cardiovascular changes may occur. On the other hand, significant reduction of AST and ALT in the diabetic group are contrary to the work of Shabab et al (2024) which reported increase in diabetes mellitus. Increased ALT and AST are related to plasma membrane damages, cell necrosis or apoptosis (McGill, 2016; Ndrepepa, 2021). Also ALT and AST can be elevated in cardiac failure (Wu, et al, 2021), acute myocardial infarction (Piper et al, 2021) and serve as good prognostic factor in MI patients (Shabab et al, 2024). In this study AST and ALT levels were reduced significantly. The reason for the AST and ALT reductions is yet to be investigated. In a cohort study, diabetes mellitus patient with 6 years follow up showed no association between AST and all the causes of CVD (Zoppini et al, 2016) but a mega cohort study report supported existence of significant association between AST and risk of myocardial infarction or ischemic stroke with over 9 years of follow up (Choi et al, 2018). Moreover, a different study observed inverse correlation between diabetes and AST in myocardial infarction (Ndrepepa et al, 2020). This implies duration dependent effect of diabetes on existence of meaningful AST difference in cardiac abnormality. Therefore, the inverse relationship indicates severity of diabetes and myocardial infarction being represented by decreased AST level. The epidemiological studies supporting elevation of AST in cardiovascular disease is faced with limited evidence and weak assertion. Therefore, either elevation or reduction of AST level signify clinical abnormalities. According to Ndrepepa et al (2020), either ways signify increased cardiovascular risk or cardiovascular disease with sever liver or kidney complications and vitamin B6 deficiency respectively. However, the mechanism involved in the observed elevation or reduction requires more investigation.

The results of serum levels of these biomarkers; CK-MB, Troponin, BNP, LDH were reduced in aqueous extract treated group. The reduction was significant on CK-MB and LDH but BNP was marginal when compared with diabetic group and not with control group. The results suggest possible amelioration of hyperglycemia induced cardiac injury in diabetes mellitus. In previous study, aqueous leaf extract of T. catappa was reported to reduce pro-inflammatory cytokines (Ben et al 2019a) and lipid peroxidation in diabetic rats (Ben et al, 2021). Oxidative stress and inflammation are established mechanism of diabetes cardiomyopathy. Therefore, it is suggested that the T. catappa effect on the cardiac biomarkers may involve anti-oxidative stress or anti-inflammatory pathways in the reduction of diabetes related cardiac injury. These results

were similar to that of insulin treated group suggesting relativity in the potency of the aqueous extract to that of insulin on these parameters.

On the other hand, significant increases were observed in troponin, BNP and CK-MB but significant decrease in LDH in diabetic groups treated with ethanol extract, methanol extract and aspirin respectively. The increase was significantly higher compared with control, diabetic and diabetic+insulin treated groups. The reason for the observed increases of these cardiac biomarkers in ethanol and methanol extracts treated groups are yet to be understood. The elevation of these cardiac markers may represents effects due to presence or absence of some phytoconstituents. Moreover, the AST and ALT levels were reduced further by all the extracts compared with control but the methanol and ethanol treated groups showed increase compared to diabetic group although the level was less than the control group values.

Comparing the results of these groups with that of aspirin treated group showed some similarity. The result of troponin, CKMB and BNP in aspirin treated group were significantly higher and LDH significantly lower than the control and diabetic groups. Many studies have reported cardio protective function of aspirin in diabetic and non-diabetic conditions (Zhenjun et al, 2021). In clinical practice, low dose aspirin is usually prescribed for established cardiovascular disease (Baigent, 2009) but the existing controversy on therapeutic use of aspirin in primary or secondary cardiovascular complications in diabetes mellitus (Bowman et al, 2018; Mahmoud et 2019; Zheng and Roddick, 2019) is unresolved. The controversy on safety of aspirin therapy due to reported adverse effects such as bleeding in gastrointestinal tract (Gargiulo et al, 2016), brain (Capodanno and Angiolillo, 2016) limits the use of aspirin in diabetes related cardiovascular abnormalities. Elucidation of the mechanism involved in the elevation of these biomarker in methanol and ethanol treated groups may provide insight to observed similarity of their effect with that of aspirin.

The low insulin level in diabetic group was raised significantly in all the experimental groups. Thus, aqueous T. catappa leaves extracts may activate mechanisms beyond increased insulin level to cause reductions in the cardiac biomarkers. This assumption is based on elevation of insulin in methanol extract, ethanol extract and aspirin treated groups without concomitant decrease in their cardiac biomarkers. Although the aqueous extract of Terminalia catappa in this study showed its cardio protective properties by reducing cardiac biomarkers compared to diabetic group, the methanol and ethanol extracts rather present a state of cardio toxicity. The observed cardiotoxicity requires further investigations in the ethanol and methanol extracts treated group

Conclusion

The conclusion of this study is that aqueous leaf extract of Terminalia catappa ameliorates myocardial injury in diabetic rats while methanol and ethanol leaf extracts are toxic to cardiac muscle.

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