



## **Protective Effects of Aqueous Extract of *Carica papaya* Leaf on the Liver of Streptozotocin (STZ)-Induced Diabetic Adult Wistar Rats**

**A. J. Ajibade<sup>1\*</sup>, P. B. Fakunle<sup>1</sup>, T. J. Adetunji<sup>1</sup> and B. D. Kehinde<sup>2</sup>**

<sup>1</sup>Department of Anatomy, LAUTECH, Ogbomoso, Nigeria.  
<sup>2</sup>Department of Biochemistry, LAUTECH, Ogbomoso, Nigeria.

### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author AJA designed the study, performed the statistical analysis. Author PBF wrote the protocol, and wrote the first draft of the manuscript. Author BDK managed the analyses of the study. Author TJA managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

*Carica papaya* Linn. (Family: Caricaceae) is a perennial, herbaceous plant used traditionally among the Yoruba tribe of Nigeria for the treatment of various human and veterinary diseases including malaria, hypertension, diabetes mellitus, hypercholesterolemia, Jaundice, intestinal helminthiasis. Therefore, this study was designed to assess some of the effects of aqueous extract of *C. papaya* leaf on the liver of Streptozotocin(STZ)-induced diabetic adult wistar rats. Experimental diabetes was induced by intraperitoneal injection of 60 mg/kg STZ freshly dissolved in 0.1M Sodium Citrate at P<sup>H</sup> buffer at 4.5. Hyperglycemia was confirmed four days after injection by measuring the tail vein blood glucose level with an Accu-Check Sensor Comfort Glucometer (Roche, Mexico City). Only the animals with fasting blood glucose levels  $\leq 200$  mg/dl were considered diabetic. A total number of 48 adult wistar rats weighing between 100 -250 g of both sexes were used for this study. The rats were acclimatized to the experimental room having

\*Corresponding author: E-mail: [adeshinaajibade@yahoo.co.uk](mailto:adeshinaajibade@yahoo.co.uk);

temperature of 25°C. Four groups were used for this study, group A served as the control which were fed with feeds and water *ad libitum* daily for six weeks and group B,C &D were induced with 60 mg/kg of STZ after which were diagnosed of diabetes after 4 days of induction. Group B served as the diabetic control group and were fed with only feed and water *ad libitum* daily for six weeks whereas, group C and D were treated with different doses of *C. papaya* extract (1.5 and 3.0 mg/100 mL) as drinking water daily for six week and were sacrificed by cervical dislocation and the liver was removed and weighed before fixing in 10% formol saline for histological procedures. The result showed a significant decrease in body weight of diabetic -induced rats ( $P<0.05$ ) while the body weights increased significantly ( $P<0.05$ ) in diabetic induced rats treated with 1.5 and 3.0 g/100 mL of the aqueous extract of *C. Papaya* leaves when the initial and final weights of the rats were compared at the end of treatment. However, the liver weights increased significantly ( $P<0.05$ ) in diabetic induced rats when compared with the diabetic rats treated with extract. The aqueous extract of *C. papaya* (1.5 and 3.0 g/100 mL) significantly decreased ( $P<0.05$ ) blood glucose levels in diabetic treated rats. There was significant increase in serum biomarker enzymes: ALT, AST and ALP in diabetic rats (Group B) at  $P<0.05$  when compared with control rats (Group A). Conversely, biomarker hepatic enzymes: ALT, AST and ALP decreased significantly ( $P<0.05$ ) in diabetic rats treated with 1.5 and 3.0 g/100 mL aqueous extract of *C. papaya* leaves when compared with both Group A and Group B. The histological section of the liver of diabetic rats treated with 3.0 g/100 mL aqueous extract of *C. papaya* leaves showed improvement in hepatic histo-architecture as the extract ameliorated hepatic morphological disruption occasioned by induced diabetes in wistar rats. This study concluded that aqueous extract of *C. papaya* leaf ameliorated hepatic induced damage in the liver of Streptozotocin(STZ)-induced diabetic adult wistar rats.

**Keywords:** Aqueous extract; *Carica papaya* leaf; diabetes; STZ; glucose level; ameliorates liver.

## 1. INTRODUCTION

Diabetes mellitus is a hereditary, metabolic, degenerative disease of the pancreas which is characterized by hyperglycemia, glucosuria, hyperlipidemia, negative nitrogen balance and sometimes ketonuria. It is caused by inability of the tissues to carry out normal metabolism of carbohydrates, fats and protein due to an absolute or relative lack of insulin. Diabetes mellitus often referred to simply as diabetes, is a condition in which the body either does not produce enough, or does not properly respond to insulin, a hormone produce in the pancreas. Insulin enables the cells to properly respond to its own insulin, does not make enough insulin, or both. This causes glucose to accumulate in the blood, often leading to various complications [1] Diabetes is a complex metabolic disorder characterized by persistent hyperglycemia resulting from defects in insulin secretion, insulin action or both. Previous report has shown that the debilitating effects of diabetes mellitus include different organ failures, progressive metabolic complications such as retinopathy, nephropathy, and/or neuropathy [2]. Similarly, diabetics are known to be accompanied by risk of cardiovascular, peripheral vascular and cerebrovascular diseases. It has been demonstrated from previous studies that several pathogenetic processes are involved in the development of diabetes, including destruction of

pancreatic  $\beta$ -cells which ultimately lead to reduced sensitivity of insulin action [3,4].

Diabetes mellitus (DM) is a common disorder associated with increased morbidity and mortality and can be defined as a group of metabolic diseases characterized by chronic hyperglycemia due to defective insulin secretion, insulin action, or both, resulting in impaired carbohydrate, lipid, and protein metabolism [5] *C. papaya* Linn. (Family; Caricaceae) is a perennial, herbaceous plant, with copious milky latex reaching to 6-10 meters tall. Its erect stem is about 30cm thick and roughened with leaf scars [6]. The unripe fruit is used traditionally among the Yoruba tribe of Nigeria for the treatment of various human and veterinary diseases including malaria, hypertension, diabetes mellitus, hypercholesterolemia, jaundice, intestinal helminthiasis [7] and for the management of sickle cell anaemia [8].

Papaya is a powerhouse of nutrients and is available throughout the year. It is a rich source of three powerful antioxidant vitamin C, vitamin A and vitamin E; the minerals, magnesium and potassium; the B vitamin pantothenic acid and folate and fiber. In addition to all this, it contains a digestive enzyme-papain that effectively treats Causes of trauma, allergies and sports injuries [9]. Several studies have reported the existence of 306 plants or fruits used as herbal remedies

for diabetes. Among them lies *C. papaya*, an herbaceous plant, member of the small family Caricaceae. This plant is widely cultivated for its edible pleasant fruit, which provides good nutritional value and easy digestion [9]. *C. papaya* Linn. (Family; Caricaceae) is a perennial, herbaceous plant, with copious milky latex reaching to 6-10 meters tall. Its erect stem is about 30cm thick and roughened with leaf scars. The unripe fruit is used traditionally among the Yoruba tribe of Nigeria for the treatment of various human and veterinary diseases including malaria, hypertension, diabetes mellitus, hypercholesterolemia, jaundice, intestinal helminthiasis [7] and for the management of sickle cell anaemia [8].

Diabetes mellitus is a condition at which the pancreas no longer produces enough insulin or cells stop responding to the insulin that is produced, so that glucose in the blood cannot be absorbed into the cells of the body. Symptoms include frequent urination, lethargy, excessive thirsty, and hunger [10]. People with diabetes are at increased risk of cardiovascular, peripheral vascular and cerebrovascular disease [11].

Diabetes causes considerable mortality and morbidity. It has no cure but effective control of blood sugar level is beneficial, especially in terms of prolonging normal life and reducing complications [12]. Diet and exercise cannot reverse or prevent type 1 diabetes. Currently, type 1 diabetes can be treated only with insulin. Hypoglycemia may lead to seizures and episodes of unconsciousness [13]. Type 1 diabetes are fatally treated with exogenous insulin. Injection is the traditional and still most common method for administering insulin, injection, indwelling catheters and inhaled insulin and these are served experimental methods as well. All replace the missing hormone formally produced by new non-functional beta cells in the pancreas. In recent years, pancreas transplant has been used to treat type 1 diabetes. Islet cell transplant is also being investigated and has been achieved in mice and rats and in experimental trials in human as well [14].

Type 2 diabetes is the most common type. In the early stage of type 2 diabetes, the predominant abnormality is reduced insulin sensitivity. At this stage, hyperglycemia can be reversed by a variety of measures and medications that improve insulin sensitivity or reduce glucose production by the liver [15]. Type 2 diabetes is

due to primarily lifestyle factors and genetics. A number of lifestyle factors are known to be important to the development of type 2 diabetes, including obesity (defined by a body mass index of greater than thirty), lack of physical activity, poor diet, stress and urbanization. Excess body fat is associated with 30% of cases in those of Chinese and Japanese descent, 60-80% of cases in those of European and African descent, and 100% of Pima Indians and Pacific islanders [15].

## 2. MATERIALS AND METHODS

### 2.1 Materials

48 wistar rats of varying body weights between 100 g-250 g, Plastic experimental cage, distilled water, feeds(growers marsh), sensitivity weighing scale, sensitivity weighing balance, permanent marker, broom, parker, gloves, water bath, microtome, containers for dyes, Streptozotocin (STZ), Glucometer, *C. papaya* leaves, Specimen bottle, EDTA bottle, 10% formal saline, Heamatoxylin and Eosin. The study was carried out at the animal house of Faculty of Basic Medical Sciences, LAUTECH, Ogbomoso, Oyo State. Wistar rats were treated in accordance with 'Guide for the care and use of Laboratory Animal' prepared and compiled by the National Academy Of Science and published by the National Institute of Health [16].

### 2.2 Sample Collection

Freshly cut matured leaves of *C. papaya* were procured from Taiwo's Hostel, Under G area, outside the campus of Ladoke Akintola University of Technology, Ogbomoso, and were identified and authenticated in the department of Pure and Applied Biology. The leaves were rinsed severally with clean tap water to remove dust particles and debris and thereafter allowed to completely drain. The collected leaves were then chopped into bits on a chopping board and air dried at room temperature 25°C -30°C for three weeks before taking to the experimental site.

### 2.3 Preparation of the Aqueous Extract of *C. papaya* leaves

The air dried leaves were pulverized using electric blender into powdery form and then carried to the Food Science and Engineering Department (Lipid Room), Ladoke Akintola University of Technology, Ogbomoso, for

aqueous extraction. 200 gms of the powdered leaves were extracted by soaking it in 2.0 litres of distilled water for 24 hours and mixed properly. The resultant mixtures were filtered with cheese cloth and the filtrate was then concentrated in a vacuum maintained at the low temperature (37-40)°C to about one tenth of the original volume using a rotary evaporator. The concentrates were allowed in a water bath (40°C) for complete dryness of aqueous extracts of *C. papaya* leaves. The filtrate was evaporated to the volume of 660mls then refrigerated at 2-8°C till the time it was used for the study.

## 2.4 Induction of Diabetes

Experimental diabetes was induced by intraperitoneal injection of 60 mg/kg STZ freshly dissolved in 0.1M Sodium Citrate at P<sup>H</sup> buffered at 4.5. Hyperglycemia was confirmed 4 days after injection by measuring the tail vein blood glucose level with an Accu-Check Sensor Comfort Glucometer (Roche, Mexico City). Only the animals with fasting blood glucose levels <200 mg/dl were considered diabetic.

## 2.5 Grouping of Animals

The animals were grouped into 4 groups namely;

Group A	12	Normal Control
Group B	12	Diabetic- Control
Group C	12	Diabetic-Treated With Aqueous Extract
Group D	12	Diabetic-Treated With Aqueous Extract

## 2.6 Administration of Aqueous Extract of *Carica papaya* leaves

The experimental animals were grouped and administered as follows;

- ❖ Animals in Group A were given feeds and water ad libitum daily for six weeks.
- ❖ Animals in Group B induced with 60 mg/kg STZ were given feeds and water ad libitum daily for six weeks.
- ❖ Animals in Group C induced with 60 mg/kg STZ were administered with 1.5 g/100 ml of *C. papaya* extracts daily for six weeks.
- ❖ Animals in Group D induced with 60 mg/kg STZ were administered with 3.0 g/100 ml of *C. papaya* extracts daily for six weeks.

## 2.7 Blood Collection and Blood Glucose Measurement

Blood sample was withdrawn from the tail vein and tested using glucose test strips and glucometer after an overnight fast.

## 2.8 Experimental Design

In order to determine the hypoglycemic effect of *C. papaya* leaves in diabetic rats, oral doses of *C. papaya* aqueous extracts (1.5 and 3.0 g/100 mL) were administered as drinking water *ad libitum*. (Perez et al. 2003). All treatments were administered as drinking water for period of six weeks after which the rats were sacrificed by means of cervical dislocation. The rats were dissected and the liver of each sacrificed experimental rat in each group was harvested. The livers were weighed before fixing them in the 10% formol saline in sample bottles for analysis.

The tissues were processed for light microscopy using the Haematoxylin and Eosin staining techniques as previously described [17].

## 2.9 Assay for Biochemical Parameters

The assay for AST and ALT was done based on the principles and model described by previous author [18] (Bergermeyer et al. 1978). Similarly, assay for ALP was carried out as described by previous investigator [19] (Schlebusch et al. 1974)

## 2.10 Statistical Analysis

Data were expressed using Graphpad prism 6. Data were expressed as Mean ± Standard error of mean (Mean ± S.E.M). Means, values were compared using one-way non-parametric Student's t-test. P- value less than 0.05(P <0.05) was taken to be statistically significant.

## 3. RESULTS

Group A(Control) increased from (141.7-160.4), Group B(Diabetic) decreased from (165.5-85.00), Group C increased from (138.6-161.4), Group D increased from (179.2 -204.2) <sup>a</sup>Represents significant decrease at P<0.05 when compared with Group A (control) <sup>b</sup>Represents significant increase at P<0.05 when compared with Group B( diabetic), <sup>c</sup>Represents significant increase at P<0.05 when compared with Group A(Control) & <sup>d</sup>Represents significant decrease at P<0.05 when compared with Group B (Diabetic).

Group B shows a significant decrease in weight at P <0.05 at final weight, Group C and Group D show a significant increase in weight at P <0.05 at final weight when compared with Group B and only significantly increase in Group D at P < 0.05 at final weight when compared with Group A.

The results showed a significant weight gain in Group A, C & D, while there was a significant weight loss in Group B diabetic-rats. Group B shows a significant decrease in weight at P <0.05 at final weight, Group C and Group D show a significant increase in weight at P <0.05 at final weight when compared with Group B and only significantly increase in Group D at P < 0.05 at final weight when compared with Group A.

There was a significant (<sup>a</sup>) increase in the organ weight in group B (diabetic) rats at P<0.05 when compared with the mean weight of group A (control). Conversely, there was a significant decrease (<sup>b</sup>) in the organ weight in group C and D rats at P<0.05 when compared with Group B (Diabetic). There was no significant increase in weights of Organ in Group C and Group D at P <0.05 when compared with Group A (control).

**Alanine Aminotransferase (ALT):** ALT activity showed a significant increase in group B, group C & group D when compared with group A(Control) at P <0.05 and also a significant decrease in ALT activity in group C and group D when compared with group B (diabetic) at P < 0.05.

**Aspartate Aminotransferase (AST):** AST activity showed a significant increase in group B, group C & group D when compared with group A(Control) at P <0.05 and also a significant decrease in AST activity in group C and group D when compared with group B (diabetic) at P < 0.05.

**Alkaline Phosphatase (ALP):** ALP activity showed a significant increase in group B when compared with group A(Control) at P <0.05 and also a significant decrease in ALP activity in group C and group D when compared with group B (diabetic) at P < 0.05. However, there was increase in ALP activity in group C and group D but not significant (P >0.05).

**Table 1. Mean + s.e.m of the body weights (g) of the rats before and after the treatment**

Groups	Initial weight(g)	Final weight(g)	% weight gain or loss
Group A(Control)	141.7 + 5.618	160.4 + 4.825	13.20
Group B(Diabetic)	165.5 + 7.282 <sup>c</sup>	85.00 + 7.638 <sup>a</sup>	-48.64
Group C(Low dose)	138.6 + 6.182 <sup>d</sup>	161.4 + 9.148 <sup>b</sup>	16.45
Group D(High dose)	179.2 + 7.189 <sup>c</sup>	204.2 + 5.180 <sup>bc</sup>	13.95

Values are expressed as Mean + S.E.M of the initial and final body weights of the rats using student t-test

**Table 2. Mean + S.E.M of the liver weight after treatment**

Groups	Liver Mean ± S.E.M(g)	Relative liver weight (%)
Group A(Control)	3.278 + 0.4372	2.04
Group B(Diabetic)	5.219 + 0.4086 <sup>a</sup>	6.14
Group C (Low Dose)	4.175 + 0.4244	2.59
Group D(High Dose)	4.893 + 0.3595 <sup>b</sup>	2.40

Values are expressed as Mean + S.E.M of the Organ weights (Liver) of the rats using student t-test

**Table 3. Showing mean ± S.E.M of ALT, AST and ALP in serum of wistar rats after treatment**

Groups	ALT	AST	ALP
	Mean ± S.E.M(U/L)	Mean ± S.E.M(U/L)	Mean ± S.E.M(U/L)
GROUP A(Control)	28.13 ± 3.888	154.6 ± 2.481	15.23 ± 2.353
GROUP B(Diabetic)	66.94 ± 6.606 <sup>a</sup>	225.1 ± 18.26 <sup>a</sup>	25.73 ± 0.5041 <sup>a</sup>
GROUP C(1.5 g/mL)	49.58 ± 5.775 <sup>b,c</sup>	179.9 ± 4.695 <sup>b,c</sup>	20.23 ± 0.9359 <sup>b</sup>
GROUP D(3.0 g/mL)	40.04 ± 4.722 <sup>b,c</sup>	170.5 ± 4.958 <sup>b,c</sup>	16.45 ± 0.3915 <sup>b</sup>

Values are expressed as Mean + S.E.M of the ALT, AST & ALP in serum of the wistar rats using student t-test

<sup>a</sup>Represents significant increase at P<0.05 when compared with Group A(control), <sup>b</sup>Represents significant decrease at P<0.05 when compared with Group B(diabetic), <sup>c</sup>Represents significant increase at P <0.05 when compared with Group A(control)

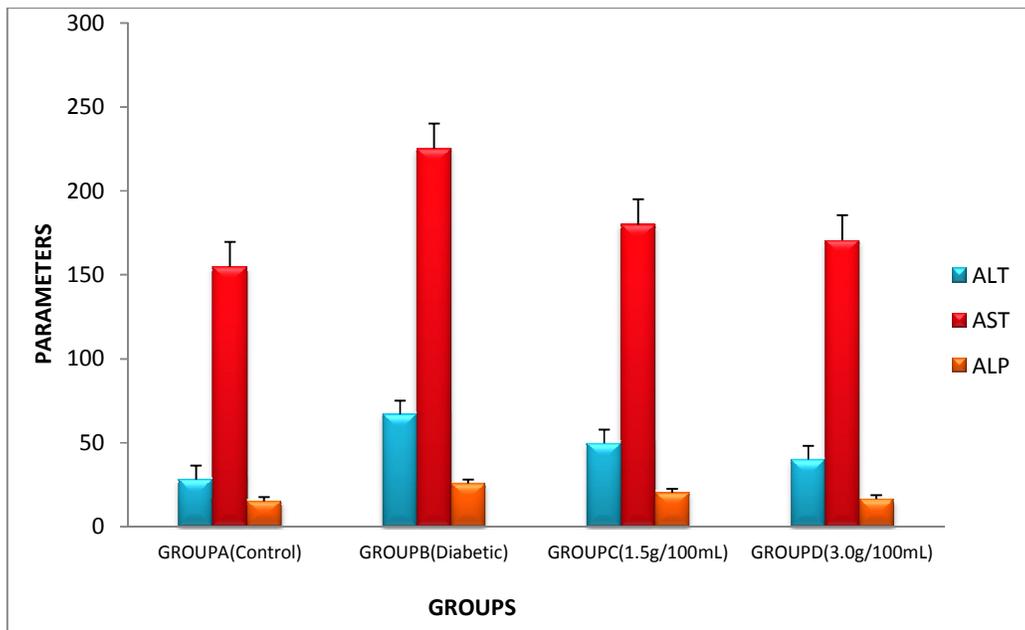


Chart 1. Showing the serum analysis of ALT, AST & ALP (U/L)

Table 4. Showing Mean  $\pm$  SEM of blood glucose level of wistar rats after treatment

Weeks	Group A Mean $\pm$ S.E.M	Group B Mean $\pm$ S.E.M	Group C Mean $\pm$ S.E.M	Group D Mean $\pm$ S.E.M
Week 0	99.42 $\pm$ 1.288	174.5 $\pm$ 60.45 <sup>a</sup>	105.5 $\pm$ 8.539	117.0 $\pm$ 7.627
Week 5	88.48 $\pm$ 4.674	206.5 $\pm$ 61.04 <sup>a</sup>	97.75 $\pm$ 5.154	77.75 $\pm$ 1.250 <sup>B</sup>
Week 6	82.09 $\pm$ 3.706	234.0 $\pm$ 47.43 <sup>a</sup>	115.3 $\pm$ 6.303 <sup>b</sup>	95.75 $\pm$ 2.626 <sup>B</sup>

<sup>a</sup>Represents significant increases at  $P < 0.05$  when compared with Group A (control), <sup>b</sup>Represents significant decrease at  $P < 0.05$  when compared with Group B (diabetic)

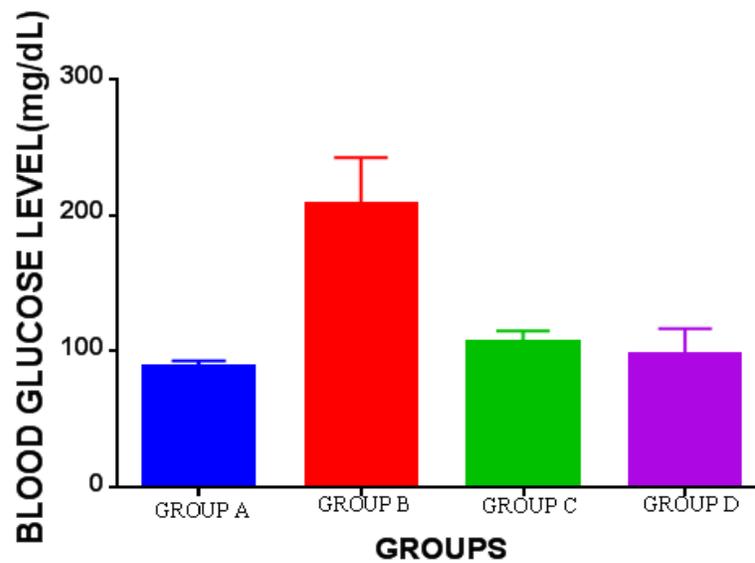
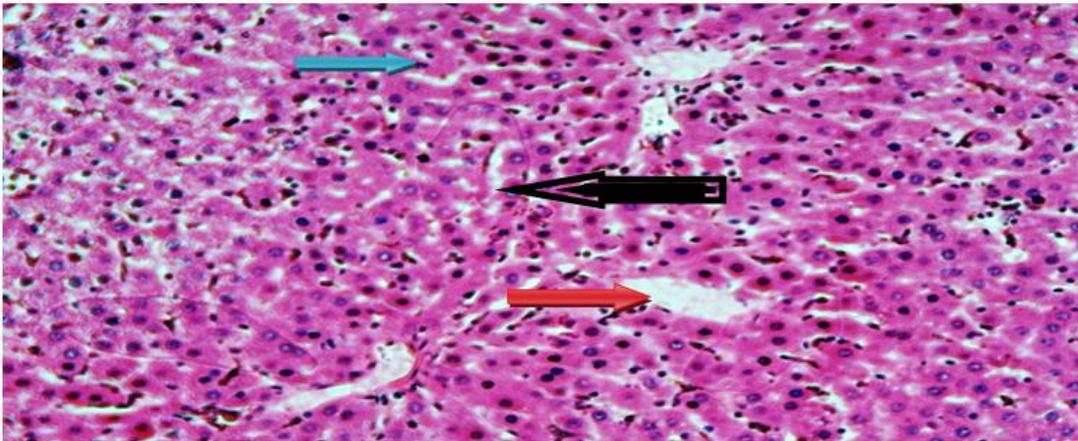


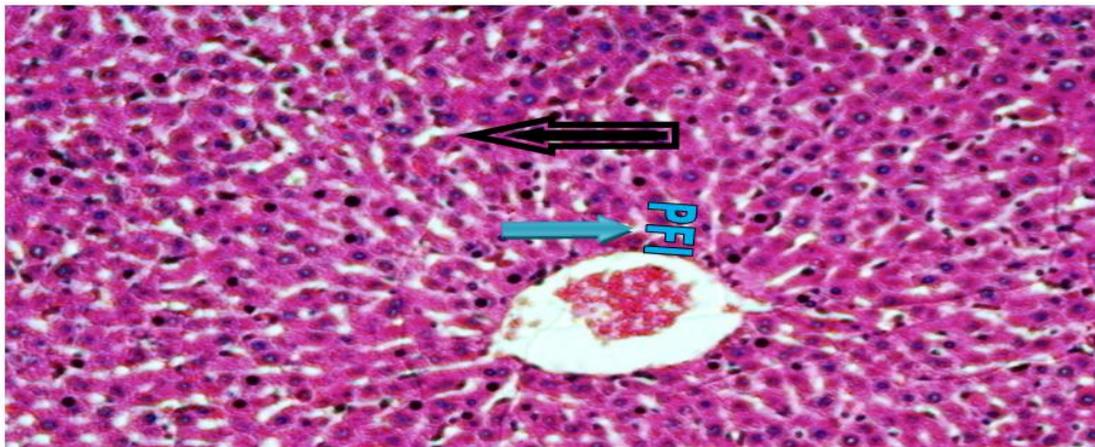
Chart 2. Showing the blood glucose level

### Photomicrograph Plates of Histological Evaluations



**Plate 1. (Control) GROUP A**

A photomicrograph of liver sections in control group (Group A) given feeds and water ad libitum for the whole period of administration (42 days) showing the normal liver microarchitecture, central vein (Red arrow), sinusoids (Black arrow), Hepatocytes (Blue arrow), no haemorrhage and there is no infiltration of inflammatory cells. X100) H&E stained



**Plate 2. (Diabetic control) Group B**

A photomicrograph of liver sections of Group B treated with 60 mg/kg Streptozotocin (STZ) for 42 days showing enlargement of central vein, distortion in the arrangement of cells around the central vein (Red arrow), periportal fatty infiltration (PFI) with focal necrosis of hepatocytes (Blue arrow) and also shows enlarged sinusoids with fatty infiltration (Black arrow) (X100) H&E stained

### 3.1 Histological Evaluations

**GROUP A (Control) Rats:** The histological sections of control rats given feeds and water ad libitum for 42 days showed normal liver architecture, liver central veins are not occluded or congested, sinusoids are normal, no infiltration of inflammatory cells seen within the liver parenchyma, and hepatocytes appear normal

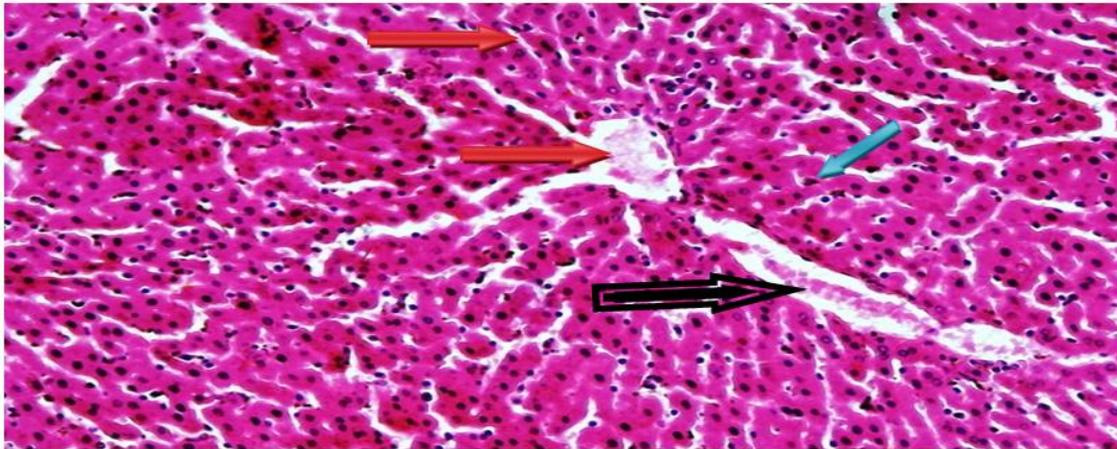
with normal morphology, no haemorrhage in H and E Stain.

**GROUP B (Diabetic Control) Rats:** The histological sections of Group B induced with 60 mg/kg Streptozotocin for 42 days showed enlarged central vein, distortion in the arrangement of cells around the central vein; periportal fatty infiltration (PFI) with focal necrosis

of hepatocytes also showed enlarged sinusoids with fatty infiltration in (X400) in H & E stain.

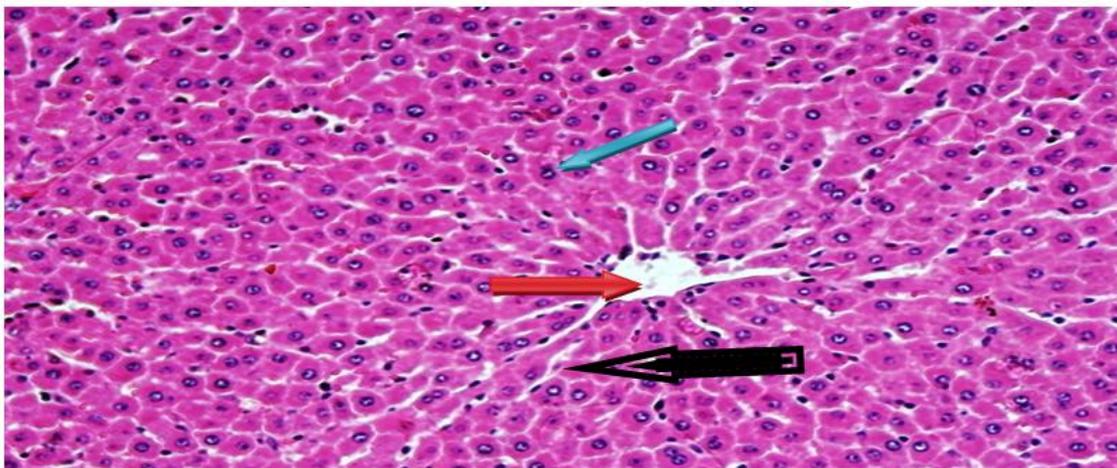
**GROUP C (treated group):** Group C rats induced with 60mg/kg Streptozotocin were treated with 1.5 g/100mL of aqueous extract of *C. papaya* for 42 days and the histological section showed normal central vein, diminished disruption of hepatocytes, enlarged sinusoids with perivenous fatty infiltration in H & E stain.

**GROUP D (treated group):** Group D rats induced with 60 mg/kg Streptozotocin were treated with 3.0 g/100 mL of aqueous extract of *C. papaya* for 42 days and the histological section of the liver of this group features central veins which are not occluded or congested, sinusoids are normal, no infiltration of inflammatory cells seen within the liver parenchyma, hepatocytes appear normal with normal morphology, no haemorrhage in H and E Stain.



**Plate 3. (Low Dose Treated Group) (1.5 g/100 mL)**

A photomicrograph of liver sections of Group C induced with 60 mg/kg STZ and treated with 1.5 g/100 mL of *Carica papaya* leaves extract for 42 days showing normal central vein (Red arrow), reduced distortion in the histology of the hepatocytes (Blue arrow), enlarged sinusoids with perivenous fatty infiltration (Black arrow). (X100) H&E stained



**Plate 4. (High Dose Treated Group) (3.0 g/100 mL)**

A photomicrograph of liver sections of Group D induced with 60 mg/kg STZ and treated with 3.0 g/100 mL of *Carica papaya* leaves extract for 42 days showing normal liver microarchitecture of hepatocytes (Blue arrow), sinusoids (Black arrow) and central vein (Red arrow) no haemorrhage and there is no infiltration of inflammatory cells compared with Group A (Control). (X100) H&E stained

#### 4. DISCUSSION

The intraperitoneal induction of Streptozotocin (STZ) to experimental rats has been shown to cause significant increase in the blood glucose levels (bgl) four days after induction. STZ is widely used to induce insulin-dependent diabetes mellitus (type 1 diabetes) in experimental animals because of its toxic effects on islet beta cells [20,21]. The diabetogenic action of STZ is the direct result of irreversible damage to the pancreatic beta cells resulting in degranulation and loss of capacity to secrete insulin [22]. The incidence and severity of lesions produced by STZ in pancreas, liver, kidney, and GIT, progressively increased with time from one to six weeks post treatment [23]. The observations and results of the present study demonstrated that streptozotocin (STZ) was effective in producing severe hyperglycemia in experimental animals and this is in agreement with the findings of previous investigators [24,25,26]. The use of conventional medical approach of simply using insulin and oral drugs to control diabetes mellitus is not only costly but inadequate, boring and lack compliance; thus patients exposure to long term complication remains a risk [27]. In response to World Health Organization (WHO), drawing attention to the use of herbal medicine as being of great importance to the health of individuals and communities [28]. Many traditional medicines in use are derived from medicinal plants minerals and organic matter. Some wild herbs and species have been shown to be most effective, relatively non-toxic and have substantial scientific documentation to attest to their efficacy in diabetes management [29].

The 42 days sub-acute studies have shown an association between hyperglycemia and decreased body weight of diabetic rats in support of previous report [30]. The present study was designed to observe some of the effects that aqueous extract of *C. papaya* leaf could have on the histology of liver of STZ-induced diabetes, to assess its effects on mean weight of rats, mean and relative weight of liver, blood glucose level and serum analysis of liver AST, ALT & ALP in adult wistar rats.

The body weight of the animals in Group A (Control Group) considerably increases in weight, the diabetic treated groups (Group C & D) with 1.5 g/100 mL and 3.0 g/100 mL of *C. papaya* extract respectively showed significant increase in body weight after treatment when

compared with control non-diabetic rats at  $P < 0.05$  (Table 1 and Chart 1).

The aqueous extract of *C. papaya* maintained the body weight of the diabetic treated rats with 1.5 and 3.0 g/100 mL aqueous extract of *C. papaya* leaves respectively (Table 1 & Chart 1) except during Week 1 and Week 2 where the body weight decreases but increase in weight was observed from Week 3 to Week 6 which may be attributed to hypoglycemic properties of the extract. Table 1 & Chart 1 also showed significant decrease in weight in Group B (diabetic) and it could be due to many factors such as loss of appetite, increased muscle waste and loss of tissue proteins, this occurred in reference to previous report [31]. It may also be concluded that the reduction in body weight was associated with increase in the relative weight of liver as observed in this study which has been similarly reported [32].

The result showed significant weight gain among the groups (Table 2 & Chart 2) except in Group B where there was weight loss, weight loss is a main sign of diabetes but its mechanism is not clear. It could be due to many factors such as loss of appetite, increased muscle waste and loss of tissue proteins, when comparing the weight of the rats before and after administration and this was supported by other report [32]. The significant weight gain reported in Group C and Group D occurred as previously reported in the findings of previous studies [33].

An increase (hypertrophy) in the weight of liver in relation to the body weight was observed in Group B (diabetic) rats compared with control non-diabetic rats (Group A) despite the fact that the mean weight of rats in Group B decreased and this agreed with other findings [34,35]. The resultant effects of these findings resulted in reduction in the relative weight of liver of diabetic rats treated with 1.5g/100mL and 3.0g/100mL *C. papaya* extract compared with the control.

This study showed that the administered *C. papaya* leaf aqueous extract (1.5 and 3.0 g/mL) in group C and D diminished significantly ( $P < 0.05$ ) the observed increased blood glucose in diabetic group B rats in a pattern as earlier reported [36,37]. In addition, this extract exhibited an antioxidant action and was not hepatotoxic at these doses (1.5 and 3.0 g/100 mL). This hypoglycemic effect is similar to the one reported for other plants [38]. Such effect may be explained in part by either a decrease in

the rate of intestinal glucose absorption or an increase in peripheral glucose utilization. In this line, some authors have ascertained increased catabolism of glucose due to GLUT4 translocation to the plasma membrane in muscle and brown adipose cells, with up regulation of the uncoupling protein-1 in brown adipose tissue and hepatic gluconeogenesis, causing as a result of hyperinsulinemia or enhancement of peripheral glucose utilization and this is also in support of report of previous investigation [33].

Histological findings showed normal histoarchitecture in the control group. Photomicrograph plates of Group A (Plate 1) reflects normal hepatocytes separated by sinusoids. The central veins show normal histoarchitecture, no haemorrhage and there is no infiltration of inflammatory cells seen within the liver parenchyma.

The histological section of Group B (diabetic control) showed enlarged central vein, periportal fatty infiltration (PFI) with focal necrosis of hepatocytes also shows enlarged sinusoids with fatty infiltration in Plate 2 and histological section as previously recorded [33].

The hypoglycemic actions of *C. papaya* extract (1.5 and 3.0g/mL) is supported by the improvement in the histological features of fat content in hepatocytes of diabetic rats and features normal histological section of liver, however, 1.5 g/mL *C. papaya* extract still features some lesions and this observation was not consistent with previous report [33]. The results of this study revealed that 1.5 g/mL suggest the aqueous extract of *C. papaya* at low dose 1.5 g/100 mL regulates bile transit and hepatic function in diabetic rats, but at high doses it could be hepatotoxic (3.0 g/100 mL), whereas the result of this study showed normal histological section under 3.0 g/100 mL of *C. papaya* extract compared to the control group.

We can therefore, deduce that extract of *C. papaya* leaves at a regulated high dose is more hepatoprotective than low dose.

Moreover, significant elevation of hepatic serum biomarker enzymes such as Aspartate aminotransferase (AST), Alanine aminotransferase (ALT) & Alkaline phosphatase (ALP) was observed in Group B (66.94 ± 6.606, 225.1 ± 18.26, 25.73 ± 0.5040 U/L, respectively) when compared with Group A (28.13 ± 3.888, 154.6 ±

2.481, 15.23 ± 2.353 U/L, respectively) at P < 0.05. has been similarly reported in the previous work [20]. Additionally, report from this study has indicated impaired liver function that may be due to hepatic damage induced by hyperglycemia (Table 4) and this is in support of previous observation reported [39]. In the present study, our results showed that *C. papaya* treatment of diabetic-induced rats (1.5 and 3.0 g/100 mL) respectively gave a significant decrease in serum aminotransferases activities (ALT and AST) in diabetic treated rats (Group C and Group D) when compared with Group A and B at P < 0.05 and only significant reduction in ALP activity when compared with Group B at P < 0.05.

## 5. CONCLUSION

This study concluded that the hepatoprotective and hypoglycemic activities of the aqueous extract of the *C. papaya* leaves in STZ –induced hepatotoxicity may involve its antioxidant and free radical scavenging activities. Also, the results of this study has shown the rationale for the folkloric use of the aqueous extract of *C. papaya* leaves in the treatment of liver disorders that may occur as a result of diabetes mellitus most especially type 1 diabetes. However, further research is required to enhance understanding of its potential therapeutic action and to corroborate findings from this study.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

All authors hereby declare that the principles of laboratory animal care [NIH publication No. 85-23 revised 1985] were followed as well as specific national laws where applicable. All experiments have been examined and approved by the relevant ethics committee.

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and therefore have been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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