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Fasting Blood - Glucose Lowering Effect of *Dacryodes Edulis* Seeds Extract

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Abstract: ***Background: D. edulis seeds extract is used in the management of hyperglycemia in folkloric medicine but with limited scientific justification. Method: The obtained n - hexane seed extract of D. edulis (NSEDE) was used to carry out acute toxicity (LD_{50}), phytochemical and anti - diabetic studies. Albino rats (20) divided into 4 groups (n=5) were used for anti - diabetic study. Diabetes was induced using Alloxan monohydrate (i. p) at the dose of 150 mg/kbw. Distilled water (10 ml/kg) and Metformin (500 mg/kg) served as negative and positive control respectively. The other two groups received NSEDE 250 and 500 mg/kg (P. O) respectively. Fasting blood sugar levels were recorded at hourly intervals and thereafter on 2nd, 4th, 6th, 8th, 10th, 12th, and 14th day. A histopathological examination of the pancreas was carried out. Results: NSEDE was safe up to the dose of 5000 mg/kg/bw. There was abundance of secondary metabolites. From the 2nd hour, a significant (P<0.05) reduction in the fasting blood sugar (FBS) was observed when compared to the control group. The daily oral treatment with NSEDE (250 and 500 mg/kg) caused a significant (P<0.05) dose–dependent reduction in the FBS when compared to the control group. There was reversal of the initial reduction in body weight of the animals. Treatment of the diabetic rats with NSEDE (250 and 500 mg/kg) and Metformin (500 mg/kg) revived the damaged pancreas. Conclusion: The folkloric use of the extract as hypoglycemic agent is justified. Recommendation: We recommend fractionation of the seed extract, with possible identification of the major compounds.***

Keywords: D *edulis* seeds, fasting blood sugar, diabetic rats.

1. Introduction

Background

Many novel chemical compounds with unique structural diversity discovered in plants have provided boundless opportunities for the discovery of new and important drugs [(1).] From time immemorial, plant extracts have been used for the prevention and treatment of many diseases [(2).] The medicinal plants still remain an exclusive source for life saving drugs for majority of the world's population especially in developing nations [(1).] The pharmacological activities of these medicinal plants have been attributed to the presence of secondary metabolites which are known to play major role in the adaptation of plants to their environment [(3).]

Dacryodes edulis (D. edulis), is generally called African plum, African pear or Safou. It is commonly known as Ube (Igbo), Mzembe (Tiv) and Olukumi (Yoruba). It is an indigenous fruit tree in the humid low lands and plateau regions of West Africa, Central African and Gulf of Guinea areas. It is an evergreen tree with relatively short trunk and a deep dense crown with a height of about 18 - 40 meters in the forest but not exceeding 12 meters in plantations The African pear tree belongs to the family *Burseraceae* [(4).]

Figure 1: Fruits of *Dacryodes edulis*

Ethno medicinal uses: Different part of *D. edulis* have been used in the treatment of various diseases in ethnomedicine [5]. The crushed bark of D. edulis tree when mixed with palm oil is applied topically to relieve pains and stiffness [5]. The leaves when boiled in pap water (decanted water from ground fermented grains) are administered to children to treat retarded growth and epilepsy [6]. The boiled leaves and roots are usually administered orally for the treatment of hypertension [6]. The leaves can also be eaten raw with kola nut as an antiemetic. The leaf sap is instilled into the ear to treat ear problems and a decoction of the leaves can be prepared as a vapor bath for treatment of feverish conditions [7]. The seeds are used traditionally as a remedy for diarrhea, dysentery. Recently [8] reported the leaves are made into plaster to treat snakebite in South - west Cameroon.

Presently, the seeds of D. *edulis* are treated largely as a waste. Instances abound where formerly regarded waste materials were turned into a useful product [9].

Prevous pharmacological studies on D. *edulis*:

Phytochemical analysis: The preliminary phytochemical screening for secondary metabolite of *D. edulis* raw seed extract had revealed some plant metabolites such as saponins flavonoids, taninns[10]. Mineral elements such as phosphorus, calcium, magnesium, potassium, sodium, zinc and manganese were also found in the pulp and seed of the plant [11]. Unlike other oily fruits, the seed oil possesses the same fatty acids as the fruit pulp and the seed may contain up to 18 - 70% oil [11].

Antimicrobial activity: Investigation of the essential oils of the plant resin for antimicrobial and antioxidant activities revealed the essential oil has more antibacterial effect against bacteria such as *Staphylococcus aureus, Bacillus cereus, Escherichia coli, Salmonella enteric* and *Proteus mirabilis* than antifungal effect against Candida albicans [12].

Antioxidant activity: The leaves of *Dacryodes edulis* elicited high antioxidant effect when analyzed against three assay methods; Fohn (Falin Ciocalteu Reagent), FRAP (Ferric Reducing Antioxidant Power) and DPPH (1, 1 - diphenyl - 2 - picrylhydrazyl) [13].

Cardiovascular activity: *Dacryodes edulis* oil was reported to decrease the HDL cholesterol level in rats [14].

Anti - sickling activity: Among the 13 Congolese plants examined for anti - sickling activity, the aqueous and ethanol extracts of *D. edulis* leaves were discovered to normalize the SS blood erythrocytes, following the deoxygenation of haemoglobin in anaerobic condition, thus validating their use in traditional medicine [15].

Toxicity: During the survey of toxic plants of Akwa Ibom State in Nigeria, D. *edulis* was not among the plants implicated for eventual toxicity evaluation. Ajibesin *et al.*, [16] supported this position when they reported lack of toxic principles in the seed of the plant. Furthermore, [17] reported absence of toxins in the fruit. .

So far, there is no record of assessment of the hypoglycemic effect of *D. edulis* seeds. The seeds are treated largely as waste. It is hoped the seeds will be put into a better use through this study considering their phytoconstituents Herbal extracts exhibit pharmacological effects through multiple mechanism [18] and *D. edulis* trees bound in our environment.

Diabetes mellitus: Diabetes mellitus is commonly known as diabetes. It is a group of metabolic disorders characterized by a high blood sugar level (hyperglycemia) over a prolonged period of time. Symptoms often include frequent urination, increased thirst and increased appetite. If left untreated, diabetes can cause many health complications [19]. Acute complications can include diabetic ketoacidosis, hyperosmolar hyperglycemic state, or death. Serious long - term complications include cardiovascular disease, stroke, chronic kidney disease, foot ulcers, damage to the nerves, damage to the eyes and cognitive impairment [19].

Diabetes could be as a result of the pancreas not producing enough insulin, or due to the cells of the body not responding properly to the insulin produced [20]. Insulin is a hormone which is responsible for helping glucose from food get into cells to be used for energy. There are three main types of diabetes mellitus; Type 1 diabetes results from failure of the pancreas to produce enough insulin due to loss of beta cells [19]. This form was previously referred to as "insulin - dependent diabetes mellitus" or "juvenile diabetes". The loss of beta cells is caused by an autoimmune response. The cause of autoimmune response is unknown. Although Type 1 diabetes usually appears during childhood or adolescence, it can also develop in adults. Type 2 diabetes begins with insulin resistance, a condition in which cells fail to respond to insulin properly [19]. As the disease progresses, a lack of insulin may also develop. This form was previously referred to as "non insulin - dependent diabetes mellitus" or "adult - onset diabetes" [19]. Type 2 diabetes is common in older adults, but a significant increase in the prevalence of obesity among children has led to more cases of type 2 diabetes in younger people. The most common cause is a combination of excessive body weight and insufficient exercise. Gestational diabetes is the third main form, and occurs when pregnant women without a previous history of diabetes develop high blood sugar levels [19]. In women with gestational diabetes, blood sugar usually returns to normal soon after delivery. However, women who had gestational diabetes during pregnancy have a higher risk of developing type 2 diabetes later in life. Type 1 diabetes must be managed with insulin injections. Prevention and treatment of type 2 diabetes involves maintaining a healthy diet, regular physical exercise, a normal body weight, and avoiding the use of tobacco [19]. Type 2 diabetes may be treated with oral antidiabetic medications, with or without insulin. Control of blood pressure and maintaining proper foot and eye care are important for people with the disease. Insulin and some oral medications can lower the blood sugar. Weight loss surgery in those with obesity is sometimes an effective measure in those with type 2 diabetes [21]. Gestational diabetes usually resolves after the birth of the baby. As of 2019, an estimated 463 million people had diabetes worldwide (8.8% of the adult population), with type 2 diabetes making up about 90% of the cases. Rates are similar in women and men [22]. Trends

suggest that rates will continue to rise. Diabetes at least doubles a person's risk of early death. In 2019, diabetes resulted in approximately 4.2 million deaths. It is the 7th leading cause of death globally. The global economic cost of diabetes - related health expenditure in 2017 was estimated at US$727 billion [23]. In the United States, diabetes cost nearly US$327 billion in 2017 [24].

The number of people with type 2 DM is increasing in every country with 80% of people living in low - and middle - income countries [25]. The prevalence of type 1 DM among patients younger than 20 years in the United States is estimated at 1.54 cases per 1, 000 youth [26].

The goal for diabetes management is to prevent or minimize chronic diabetic complications which may lead to blindness, heart disease and limb amputation. Patients with type I diabetes mellitus require direct injection of insulin as they cannot produce enough or even any insulin. Management of type II diabetics consists of a combination of diet, exercise, and weight loss, in any achievable combination depending on the patient. Patients who have poor diabetic control after lifestyle modifications are typically placed on oral hypoglycaemics. However some type II diabetics fail to respond to these and must proceed to insulin therapy [23].

Non - Pharmacological approach involves medical nutrition therapy (taking low calorie diet), weight loss, increased physical activities, blood glucose monitoring and patients - centered diabetes care [27]. However, due to poor diabetes control, most patients would require multiple therapies to achieve good glycaemic control in the long run. Some anti - diabetics include, sulphonylureas (Glibenclamide), Metiglinides (Repaglinide), α - Glucosidase Inhibitors (Acarbose). Some plants with hypoglycemic effects have been identified and they include *Allium sativum (*garlic), seed extract of *Coriandrum sativum (*coriander), aqueous leave extract of *Mangifera indica (*mango) [28] and extract of *Allium sepa* (onion) [29]

2. Materials and Methods

2.1 Materials

Sample collection, identification and preparation
D. edulis fruits were bought from Eke Awka, in Awka south local government area, Anambra state, Nigeria, in July 2021. They were identified and authenticated at Department of Botany, Nnamdi Azikiwe University, Awka, Anambra state, Nigeria by Mr. Iroka Finian and a herbarium number NAUH - 112C was assigned to it.

Drug and chemical:
Alloxan monohydrate (Zigma LTD USA), Metformin (NGC, Nigeria), N - Hexane (Sigma Aldrich).

Instruments and materials
Glass column, flasks, beakers (10, 25, 50, 100 and 1000ml), test tubes, measuring cylinders, rotary evaporator, analytical weighing balance (Metler H30, Switzerland), Acuanswer glucometer and strips, plastic cages, drinkers, micropipette (Finnipipette® Labsystems, Finland), feeding syringes, latex gloves, hand towels, dissecting forceps, dissecting scissors.

The animals
The study was carried out using adult albino rats (200 to 220 g) of both sexes bred locally in the Animal House of the Department of Pharmacology & Toxicology, Faculty of Pharmaceutical Sciences, Chukwuemeka Odumegwu Ojukwu University Igbariam campus Nigeria. The ethical approval (PHACOOU/AREC/2021/007) was also obtained from the same University. The Rats were fed with feed pellets, Top Feed (by Premier Feed Mills Sapele, Delta state, Nigeria). The animals were given food and water *ad libitum* throughout the experiments. They were kept in specially constructed cages to prevent coprophagia during and after the experiment.

2.2 Methods

Extraction
The seeds of *D. edulis* were removed from the fruits; air dried for three weeks at room temperature, and then pulverized using a Binatone blender BLS 450 to obtain a powdered form of the seeds. The powdered seeds (I kg) was soaked in 1 litre of n - hexane for 24 h, filtered by passing it through a cotton plug and further filtered with filter paper (Whatman filter paper, No 1). The n - hexane seed extract of *D. edulis* (NSEDE) so obtained was dried using rotary evaporator at 40°C to a constant weight. The yield of the crude extract was calculated as percentage of plant material used for the extraction. The powdery ash - colored extract was poured into an amber - colored bottle and stored inside refrigerator until required for experiments

Qualitative phytochemical analysis
Phytochemical tests were carried out on the seed extract to identify the presence of tannins, flavonoid, alkaloid, cardiac glycosides, terpenoid, anthraquinone and steroid using the method described by [30].

Acute toxicity study (LD50)
The acute toxicity (LD50) test of the n - hexane seed extract of *D. edulis* was determined using the up and down method as described by [31]. The LD_{50} value of a test substance was estimated by testing individual animals sequentially, with the dose for each animal being regulated up or down based on the results of the preceding tests. Animals were dosed one at a time. The dose for the next animal is increased by a factor of 3.2 if the preceding animal survives, while the dose is decreased by a factor of 3.2 if the animal dies. It took 1 day to observe each animal before dosing the next animal. A total of 6 rats were used for the study with 3 albino rats serving as control (distilled water 10 ml/kg p. o). Thereafter, animals that survive the test were monitored for delayed toxicity for 7 days ([31].

2.3 Anti - diabetic study on NSEDE

Induction of experimental diabetes in albino rats
Alloxan monohydrate was used to induce experimental diabetes in the rats using the method described byKannur *et al, (*[32]. Animals were fasted for 24 hours, with free access to water and diabetes was induced by injecting a single dose of 150mg/kg body weight of alloxan monohydrate intraperitonially. The alloxanized rats were kept for 3 days with free access to feed and water for hyperglycaemia to

develop. Baseline fasting blood glucose levels were determined using Acuanswer Glucometer. Rats with glucose levels above 200 mg/kg were separated and used for the study. Dose of extract to be administered to the diabetic rats were determined from the LD_{50} as described by Neharkar and Galkwad ([33]).

Animal grouping and treatment

The 20 albino rats were divided into 5 groups (n=5) and were treated as follows:

Group 1: Distilled water 10ml/kg/bw (Negative control)
Group 2: Metformin 500mg/kg/bw (positive control)
Group 3: NSEDE 250mg/kg/bw
Group 4: NSEDE 500mg/kg/bw

After grouping, the baseline blood glucose level (zero hour) of rats were taken with the aid of Acuanswer glucometer. The diabetic animals were then treated as stated above. The blood glucose were measured at 2nd, 4th, 6th, 8th and 10th hours respectively using blood collected from the tail of the diabetic rats ([34, (35)].

This was then following by daily oral administration of the crude NSEDE (250mg/kg and 500mg/kg) and Metformin (500mg/kg) as stated above for a period of 14 days. Blood glucose levels were measured on days 2nd, 4th, 6th, 8th, 10th, 12th and 14th with the aid of the glucometer. At the end of the study, the animals were sacrificed with excess chloroform and their pancreas collected for histology studies ([34]).

Effects on body weight

The effect on body weight was studied by recording the body weights of the albino rats before induction of diabetes and after the study.

Histological study of the pancreas

Histological study of the pancreas specimen was carried out using the method described by ([36]). The harvested pancreas tissues which were preserved on 10% formaldehyde solution were dehydrated in ascending grades of ethanol, cleared in xylene and embedded in paraffin wax. Sections (6mm in thickness) of the tissues were prepared and stained with Haematoxylin and Eosin and subsequently examined under microscope.

Statistical analysis

The data were analyzed by statistical package for social sciences (SPSS version 20) using one way ANOVA, followed by post - hoc turkey's test for multiple comparisons. The data were expressed as ± Standard error of mean (SEM). Graphical representation was done using Microsoft excel 2020. The difference between mean were considered significant at $p<0.05$.

3. Results

Yield of extract

The % yield of the extract (NSEDE) was found to be 68% w/w

Acute toxicity test (LD50)

The extract did not cause any sign of toxicity nor death in the albino rats up to the dose of 5000 mg/kgbw. D. *edulis* seed extract could therefore be considered relatively safe.

Pytochemical analysis

The preliminary qualitative phytochemical analysis of NSEDE revealed the presence of flavonoids, saponins and terpenoids in moderate amount while phenol, alkaloids and anthraquinone were in abundance. However, we observed the absence of tannins in NSEDE (Table 1)

Table 1: Qualitative phytochemical anlysis on n - hexane seeds extract of D. edulis

Test	Terpenes	Flavonoids	Saponin	Terpenoid	Tannins	Phenol	Anthraquinone	Alkaloids
Obs	++	++	++	++	-	+++	+++	+++

Key: +=trace or mildly present, ++=moderately present, +++= abundantly present, - =absent

The hourly effect of n - hexane seed extract of *D. edulis* on fasting blood sugar

After 2 hours of oral administration of NSEDE (250mg and 500mg/kg), a significant ($P<0.05$) reduction in the fasting blood sugar levels of the diabetic rats were observed when compared to the control group. This significant reduction started to manifest from the 2nd hour then continued to the 10th hour of treatment (Table 2).

Daily effect of n - hexane seed extract of *Dacryodes edulis* on fasting blood sugar level

The daily oral treatment of the diabetic rats with NSEDE (250 and 500 mg/kg) was able to cause a dose - dependent significant ($P<0.05$) reduction in the fasting blood sugar (FBS) of the diabetic rats when compared to the control group (Table 4). There was a consistent reduction in FBS caused by NSEDE (250 and 500 mg/kg) and metformin (500 mg/kg) treated groups as from day 6th. The FBS levels obtained on day 12th and 14th for NSEDE 500 mg/kg dose (130.0±0.87* and 90.2±1.45* respectively) and metformin 500 mg (129.2±0.35 and 94.60±0.64 respectively) were comparable (Table 3).

Effect of NSEDE on body weights of the diabetic rats

A significant ($P<0.05$) increase in body weight occurred only in the rats treated with 500 mg/kg NSEDE and 500mg/kg Metformin (Table 4)

Table 2: Hourly effect of NSEDE on fasting blood sugar level

Treatment	Dose/kg	FBS (mg/dl)					
		0 hr	2nd hr	4th hr	6th hr	8th hr	10th hr
Dist/ water	10ml	330± 0.44	334.6±0.64	335.4±1.48	340.8±0.67	344.6 ±1.44	347.00±2.13

Metformin	500mg	384.8± 0.65	300.4±0.89*	286.00±0.78*	285.4 ±0.52*	280.6 ±1.47*	278.2 ±0.36*
NSEDE	250 mg	376.0±0.24	330.4±0.99*	308.6±0.35*	305.2 ±0.24*	299.0 ±0.34*	282.2±0.52*
	500 mg	449.2±0.38	310.21±0.2*	298.4±1.23*	290.8 ±0.41*	285.4 ±2.40*	277.4±0.41*

Values are presented as mean ± Standard error of mean (SEM), n =5. Key: FBS=blood sugar, NSEDE=n - hexane seed extract of *Dacryodes edulis*, *=statistically significantly different from the control group.

Table 3: Daily effect of NSEDE on fasting blood sugar level

		FBS (mg/dl)							
	Dose/kg	Day 0	Day 2	Day 4	Day 6	Day 8	Day 10	Day 12	Day14
Distilled water	10ml	347.00±2.13	349.6 ±0.87	353.6 ±1.44	358.8 ±1.55	361.8 ±2.41	365.2 ±0.66	371.6 ±1.24	395.8 ±1.44
Metformin	500 mg/kg	366.2±0.36	356.2 ±1.11	345.4 ±0.48	325.0 ±2.16*	230.8 ±0.46*	195.6 ±0.21*	129.2 ±035*	94.60 ±0.64*
NSEDE	250 mg/kg	353.2±0.52	342.6 ±0.65	332.4 ±0.24*	319.8 ±1.81*	236.2 ±0.49*	196.00 ±0.34*	159.0 ±2.43*	119.2 ±0.65*
	500 mg/kg	435.4±0.41	387.4 ±1.94	363.0 ±0.64	343.8 ±1.11*	253.8 ±1.24*	188.4 ±2.48*	130.0 ±0.87*	90.2 ±1.45*

Values are presented as mean ± Standard error of mean (SEM), n =5.
Key: FBS=blood sugar, NSEDE=n - hexane seed extract of *Dacryodes edulis*, *=statistically significantly different from the control group

Table 4: Effect of various treatments on body weight

Treatment	Dose	Weight 1	Weight 2
Distilled water	150mg/kg	188.0±2.33	136.5±3.41
Metformin	500 mg/kg	157.96±0.47	173.76±2.33*
NSEDE	250 mg/kg	180.94±0.28	175.6±1.46
	500 mg/kg	172.74±1.41	219.86±1.40*

Values are presented as mean ± standard error of mean (SEM), n=5.
Key: NSEDE=n - hexane seed extract of *Dacryodes edulis*, *=statistically significantly different from the control group, weight 1= weight before treatment, weight 2=weight after the treatment.

Histopathology

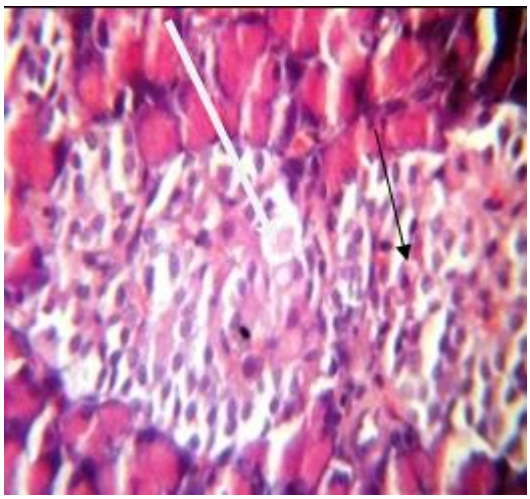

Figure 2a: Control. The pancreas of the negative control was severely degenerated. Diabetic pancreas features show some acinar cells with islet - cells, congested pyknotic nuclei (black arrow) with visible lymphocytic infiltrates (white arrow). The histoarchitecture was deeply affected

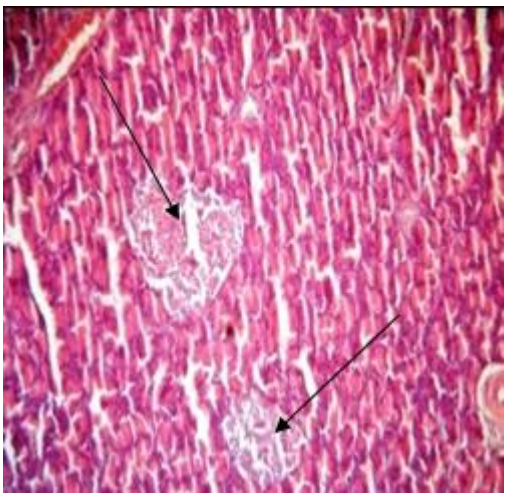

Figure 2b: Diabetic rat treated with 500mg/kg metformin, Pancreas features show some acinar cells with islet - cells, mildly despaired pyknotic nuclei and mild Lymphocytic infiltrates. Histoarchitecture was slightly affected (black arrows)

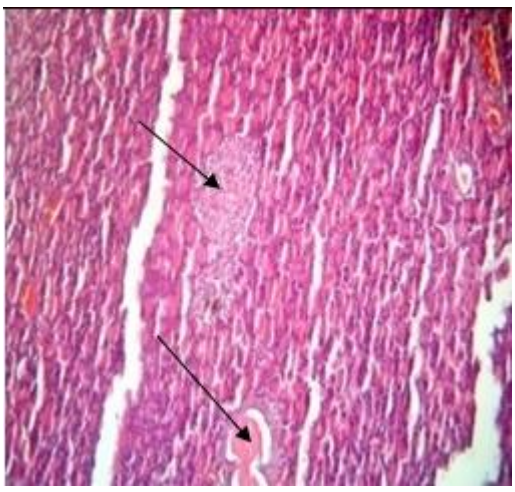

Figure 2c: Diabetic rat treated with 250mg/kg of NSEDE, reaveals secreterory acini with bulky pancreatic islet (black arrow). The nucleus appears pyknotic. Histoarchitecture was slightly affected

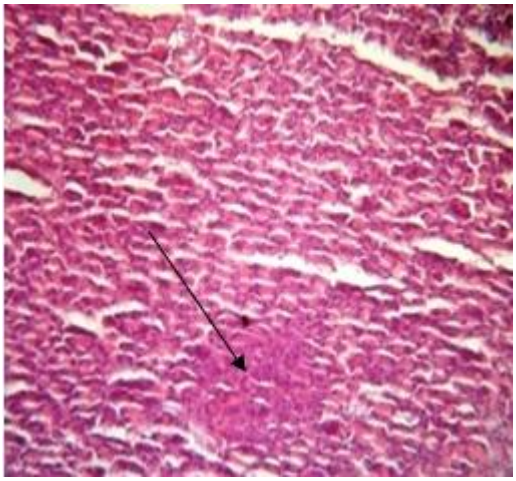

Figure 2d: Diabetic rat treated with 500 mg/kg of NSEDE, revealing secreterory acini with bulky pancreatic islet (black arrow). The histology also reveals intralobular duct at low power. Histoarchitecture slightly affected.
Figure 2: Histopathology of the control and treated diabetic Rats

4. Discussion and Conclusion

3.1 Discussion

Diabetes mellitus is recognized as chronic metabolic disorder that causes high morbidity and mortality [37]. Glycemic homeostasis refers to glucose balance or control within circulation in living organisms. Glycemic homeostasis is largely compromised in diabetes. This compromised glycemic homeostasis when exacerbated, leads to several complications including retinopathy, nephropathy and neuropathy which are the principal actors in co - morbidity and eventual mortality often associated with diabetes. The ability of therapeutic compounds including medicinal plants to restore glycemic balance or homeostasis in hyperglycemic condition is an index of their antidiabetic function and relevance (htts: //medlineplus. gov>article).

Phytochemical analysis of n - hexane seeds extract of D. *edulis* (NSEDE) revealed abundance of anthraquinones, phenols and alkaloids. There is moderate terpenes, flavonoids and saponins . Saponins from plants and marine animals have been reported to possess hypoglycemic activity [38] The acute toxicity study on NSEDE revealed its safety up to the dose of 5000 mg/kg, suggesting the extract is relatively safe. NSEDE at 250 and 500 mg/kg dose significantly (P<0.05) reduced the fasting blood sugar levels in the diabetic rats when compared to the control from 2nd hour to the 10th hour of treatment. Likewise, daily oral treatment of the diabetic rats with NSEDE (250 and 500 mg/kg) caused a dose - dependent significant (P<0.05) reduction in the fasting blood sugar of the diabetic rats when compared to the control group. Alloxan is a popular diabetogenic agent used for assessing the antidiabetic or hypoglycemic capacity of test compounds. Alloxan monohydrate is known to induce diabetes by a mechanism which basically involves partial degradation of the beta cells of pancreatic islets and subsequent compromise in the quality and quantity of insulin produced by these cells [39].

Insulin is a hormone produced in the pancreas by special cells called beta cells, it is needed to move blood sugar (glucose) into the cells, where they are stored and later used for energy (htts: //medlineplus. gov>article).

Alloxan monohydrate diabetic model employs two distinct pathological effects which include selective inhibition of glucose - stimulated insulin secretion, and induced formation of reactive oxygen species (ROS) which promotes selective necrosis of beta cells of the pancreas [39].

It could therefore be that the NSEDE was able to revive these partially degraded beta cells leading to subsequent reduction in fasting blood sugar. From the phytochemical analysis NSEDE was found to contain phytochemicals which have been previously reported of having antioxidant and anti - diabetic activities. The radical scavenging activity of natural anthraquinones and phenol have been reported ([40] respectively. In a study carried out by ([41] the alkaloids were found to have higher antioxidant activity than the phenols. The anti oxidant property of flvonoids has been linked to their ability to reduce free radicals formation as well as scavenge free radicals ([42]. Saponin can reduce the increment of blood glucose by inhibiting the enzymes that break down disaccharides into monosaccharides. This effect is remarkable for the treatment of both Type I and Type II diabetic patients and helps to prevent high blood sugar levels postprandial ([43]. Hence it is possible these pharmacological activities which are associated with thse phytochemical may have contributed to the ability of NSEDE to reduce the FBS of the diabetic rats. The ability of NSEDE to increase the body weight of the diabetic rats after the initial decrease in body could be attributed to its ability to control the FBS.

The histological analysis of the pancreas of the negative control revealed a severely degenerated pancreas, but treatment of the diabetic rats with NSEDE (250 and 500 mg/kg) and Metformin (500 mg/kg) were able to revive these damaged pancreas as was observed in figure 2b, 2c and 2d. It is believed that beta cell can regenerate through the replication of pre - existing beta cells or neogenesis from stem cells and progenitor cells inside or outside the islets [1]. Therefore NSEDE ability to revive these damaged beta cells could also be linked to the radical scavenging properties of its phytoconstuents as stated above

3.2 Conclusion

The seed extract of *D. edulis* is relatively safe as well as having anti - diabetic effects. The use of the seed extract in treatment of high blood glucose in folklore medicine is justified. The anti diabetic effects could be related to the strong antioxidant properties of its phytoconstituents, especially those which were in abundance.

5. Recommendation

We recommend fractionation of the seed extract, with possible identification of the major compounds.

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