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Comparative antihyperglycemic potentials of different fractions of *Detarium senegalense* stem bark extract on streptozotocin-induced diabetic Wistar rats

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Abstract

Aim: The search for cheap and potent antidiabetic agent with less adverse effects and efficient glycemic control than orthodox and allopathic therapies prompted this current study.

Method: Forty-two (42) adult Wistar rats of between 150-200g were procured and acclimatized for two weeks for the study. They were first grouped into six (6) of seven rats (n=7) per group. Whilst group 1 received normal water and *chow ad libitum* (control), groups 2-6 respectively were steptozotocin (STZ)-induced diabetic, untreated (diabetic control), 50mg/kg metformin treated diabetic, STZ-induced, 250mg/kg body weight of *D. senegalensis ethyl acetate* extract treated, STZ-induced, 250mg/kg of *D. senegalensis n-hexene* extract treated, and 250mg/kg bw of *D. senegalensis chloroform* extract treated. While using the GCMS to analyze the active ingredients of the various *D. senegalensis* fractionates administered, fasting blood glucose levels were checked and compared weekly for 10 weeks before and during treatments; obtaining differences in mean with the one-way analysis of variance (ANOVA). All test statistics were performed with the graph pad prism 8.1, setting $p < 0.05$ as statistically significant.

Results: Study observed the highest anti-diabetic bioactivity in experimental than control animals; especially confirming the presence of major phytochemicals but Glycosides. In diabetic rats, a significant increase was observed in α-amylase and α-glucosidase activities, but with administration of chloroform, Hexane and Ethyl acetate fractions from the methanol stem bark extract at 250 mg/kg and metformin (50 mg/kg) significantly decreasing the activity of the enzyme's ability on the pancreas, with the most potent being the ethyl acetate extract group

Conclusion: *D. senegalense extract* proved to be a potent alpha-glucosidase inhibitor with less potency for alpha-amylase. This action could be productive in preventing DM via decrease in blood glucose uptake.

Keywords: Diabetes mellitus; *Deterium senegalense*; Phytochemical ingredients; Hypoglycemia

1. Introduction

Characterized by an abnormal and chronic increase in blood glucose level, Diabetes mellitus (DM) is a metabolic disorder, consistent polyuria, visual impairment, blindness, kidney disease, nerve damage, heart disease, and the loss of glucose homeostasis due to loss of insulin production or the effective utility of insulin or both [1]. It is one of the

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world's commonest metabolic diseases affecting both the rich and poor with 347 million people reported worldwide to be suffering from diabetes [2].

Few studies have evaluated the antidiabetic property of *Detarium senegalense*; its blood glucose lowering potency and its metabolic effects on various organ systems [3]. A study specific (for example) to its reduction capability on blood glucose via the metabolic pathway was carried out by David et al., [4]. Their findings showed that ethanolic fraction of *D. senegalense* root extract reduced as much as 67.3 % of blood sugar level compared to glibenclamide (57.5 %) at the 32nd hour of care on diabetic rats at a maximum dose of 2000 mg/kg of extracts. Herbal *D. senegalense* plant has been studied over the years and found to contain several secondary metabolites which points to its use and potency. A study on the phytochemistry of its stem bark extract revealed the presence of secondary metabolites such as alkaloids, tannins, flavonoids, terpenes and steroids, saponins and glycosides [5]. Albeit, reports within the last decade have proven *D. senegalense* aqueous extract as traditionally efficacious in the management of bronchitis, pneumonia, intestinal complaints and skin diseases in tropical Africa.

Although the exact mechanism by which *D. senegalense* extract potentiate the aforesaid hypoglycemic effect on diabetic animals remain speculative and unexplored by researchers, a far more debilitating concern is the drawback that oral hypoglycemic agents are most often disdained by diabetic subjects with non-compliance. These also favored in-depth studies to find new medications that can better treat type 2 diabetes with less to no side effects [6]. As the demands for such drugs grow, especially in African rural areas, indigenous, low-cost herbal preparations as anti-diabetics have emerged, either as crude, ethanolic or distilled drugs [7]. It is against this backdrop that current study aimed at evaluating the potent antidiabetic activities of different stem bark extracts of *D. senegalense*, a leguminous *Detarioideae* on Streptozotocin-Induced, diabetic Wistar Rats

2. Material and methods

2.1. Sample Collection and identification

Fresh stem bark of *D. senegalense* was obtained from its growing habitat in Chaza village, Suleja Local Government Area, Niger State, Nigeria. It was identified and authenticated by Mallam Ibrahim Muazzam (an ethnobotanist) of the department of Medicinal Plants and Traditional Medicine, National Institute of Pharmaceutical Research and Development, (NIPRD) Abuja Nigeria. A voucher specimen number NIPRD/H/7082 was allocated to it and deposited at the herbarium of the Institute for reference.

2.2. Plant Extraction

Fresh stem bark of *D. senegalense* was collected, washed, air-dried and ground into a fine powder and the weight of the powder was measured with Mettler weighing balance instrument. 1500g of the powder was soaked in 6 litres of methanol for 48 hours. The mixture was filtered using Whatman's No. 1 filtered paper [1]. The extract was allowed to air-dry into a paste and stored in universal bottles and was kept at 4 o C in the fridge to be used for the experiment.

2.3. Animals

Fifty-seven (57) Adult male Wistar rats for this study (150 -200 g) were purchased from the animal house of the Faculty of Basic Clinical Sciences, Rivers State University, Nkpolu-Orowurokwo, Nigeria. They were acclimatized for seven days in well aerated cages and conditioned in a breeding chamber with the natural controlled system (room temperature and a natural 12 h-12 h light-dark cycle). The rats was allowed free access to water and fed with standard commercial pelleted feed, a product of Top Feed in Sapele, Delta State. The ethical approval of this study was obtained from the Institutional Animal Ethics Committee of the Rivers State University, Nkpolu-Oroworukwo, Rivers State, Nigeria, with the reference number RSU/FBCSEC/A/20. This research was performed in compliance with National and International Laws and Guidelines for Care and Use of Laboratory Animals in Biomedical Research prepared by National Academy of Sciences and published by the National Institute of Health [8].

2.4. Phytochemical analysis of the plant

The method as described by Aziz, 2015 [9]) was used for the assay of *D. senegalense* stem bark phytoconstituents. The metabolites analysed include tannins, saponins, alkaloids, flavonoids, terpenoids, steroids, anthraquinones and glycosides.

2.5. Phytochemistry of the fractions

GCMS machine was used to analyse the active ingredients of the various *D. senegalense* fractionates studied with the highest anti-diabetic bioactivity observed in the experimental than control animals.

2.6. Fractionation of Crude Plant Extract

The plant extract was fractionated following Ekam *et al*., [10] method. Crude ethanolic extracts were fractionated using a serial liquid-liquid separation method (Chromatography).

2.7. Fractionation procedure

About 200 ml of the crude extract of *D. senegalense* filtrate was measured with a measuring cylinder into a separating funnel (500 ml), held in place with a retort stand, and 200ml of n-hexane added. The mixture was then shaken properly and allowed to stand for 30 minutes, then allowed to separate into two layers. One layer containing hexane soluble constituents of *D. senegalense* was collected into a beaker, and the other layer comprising of non-hexane soluble filtrate. The resultant residues were left to stand in an open beaker in order for the n-hexane to evaporate. After drying, 200 ml of the residue was measured into a separating funnel, with 200 ml of chloroform be added to it, shaken properly and allowed to stand for separation. The mixture was again kept until pathed into two layers; a chloroform soluble phase and non-chloroform soluble residue. The non-chloroform soluble phase was collected, left to stand for evaporation of the chloroform, then poured into another separating funnel for the next extraction phase using ethyl acetate; again, the mixture was allowed to separate into two phases and collected as above. Thereafter, 200ml ethyl acetate residue was allowed to air-dry, filtrate allowed to slowly evaporate to dryness in a water bath at 40-50 °C to yield a semisolid substance with a percentage yield of ethyl acetate, chloroform and n-hexane. These fractionates were stored in a refrigerator to prevent bacterial decomposition, contamination and possible loss of efficacy before

2.8. Acute toxicity study

The acute toxicity test was conducted using Lorke [11] method. The method has two phases; In the first phase, 3 groups of three rats each were treated with the stem bark extract at graded doses of 10 mg/kg, 100 mg/kg and 1000 mg/kg orally and observed for signs of toxicity for 24 h. When no mortality was witnessed, the second phase was initiated. Three groups of one rat each were orally given the extract at doses of 1600 mg/kg, 2900 mg/kg and 5000 mg/kg respectively. The animals were then observed for signs of toxicity and mortality for 24 h and 48 h and 72 h for late toxicity.

2.9. Induction of Diabetes

The method of induction was adopted from Singh et al., [12]. Overnight fasted rats were made diabetic by a single intraperitoneal injection of freshly prepare streptozotocin solution at a dose of 60 mg/kg in sterile saline. Seventy-two hours after streptozotocin injection, animals having blood glucose level >200 mg/ dL were considered as being diabetic and recruited for the study [13].

2.10. Study Design

Fasting blood glucose levels and the weight of the animals was checked weekly, for a period of 10 weeks. The Wistar rats were grouped and treated daily for a period of 10 weeks as follows;

- **Group 1** (n = 7) – (Control Group)
- **Group 2** (n – 7) – (Diabetic control) STZ-induced diabetic rats
- **Group 3** (n = 7) – (Standard Group) 50 mg/kg metformin treated diabetic rats.
- **Group 4** (n = 7) – 250 mg/kg body weight of *D. senegalensis ethyl acetate* extract treated.
- **Group 5** (n = 7) –250 mg/kg body weight of *D. senegalensis n-hexene* extract treated.
- **Group 6** (n = 7) –250 mg/kg body weight of *D. senegalensis chloroform* extract treated.

2.11. Sacrificing of animals and Sample Collection

The animals were sacrificed by cervical dislocation after an overnight fast but prior to this, a final fasting blood glucose check was carried out. Laparotomy was also conducted on each animal to expose their visceral for other investigations; blood was collected by cardiac puncture, using 5ml syringes and 23G needle into plain blood sample container.

2.12. Statistical Analysis

Obtained data were expressed as mean ± standard error of mean (SEM). Statistical comparisons was performed by one-way analysis of variance (ANOVA). Where a significant difference was found, the Fisher's least significant difference (LSD) was used to confirm the specific variable responsive for the difference. The SPSS software (version 2.0) was used in the statistical analysis using multiple comparison tests. ($p < 0.05$ was considered significant.

3. Results

3.1. Phytochemical analysis

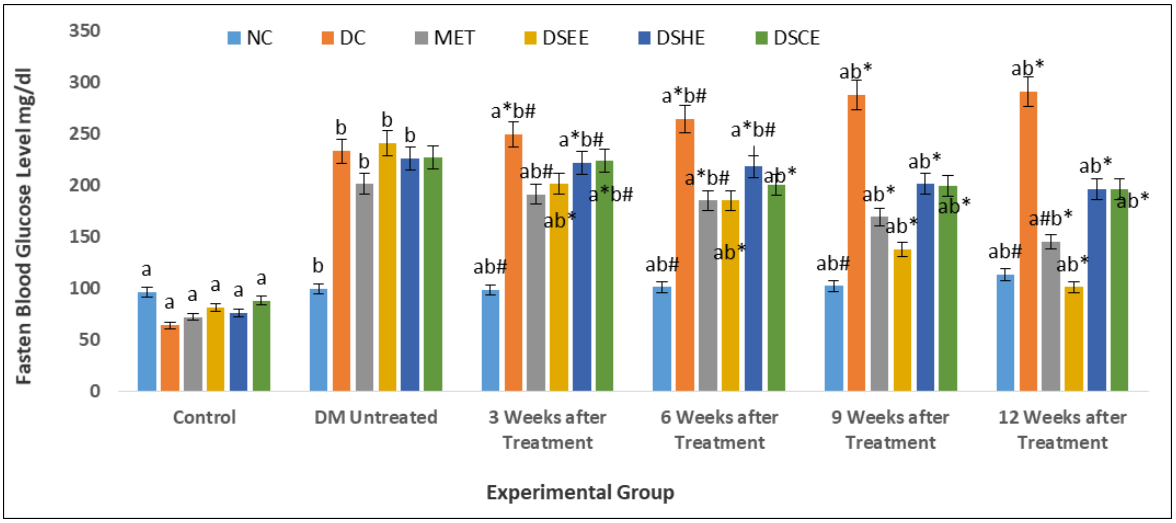
Phytochemical screening of *D. senegalense* stem bark extract contained secondary metabolites such as alkaloid, saponins, tannins, flavonoids, terpenoids, steroids, glycosides, alkaloids and carbohydrates.

3.2. Acute toxicity test

The stem bark extract of *D. senegalense* did not produce any lethality or significant toxicity signs in rats up to 5000 mg/kg bodyweight for 24 and 72 hours post-treatment.

3.3. Effects of the stem bark extract on blood glucose levels in Wistar rats

The activities of the extract on blood glucose levels in rats are shown in the figures below

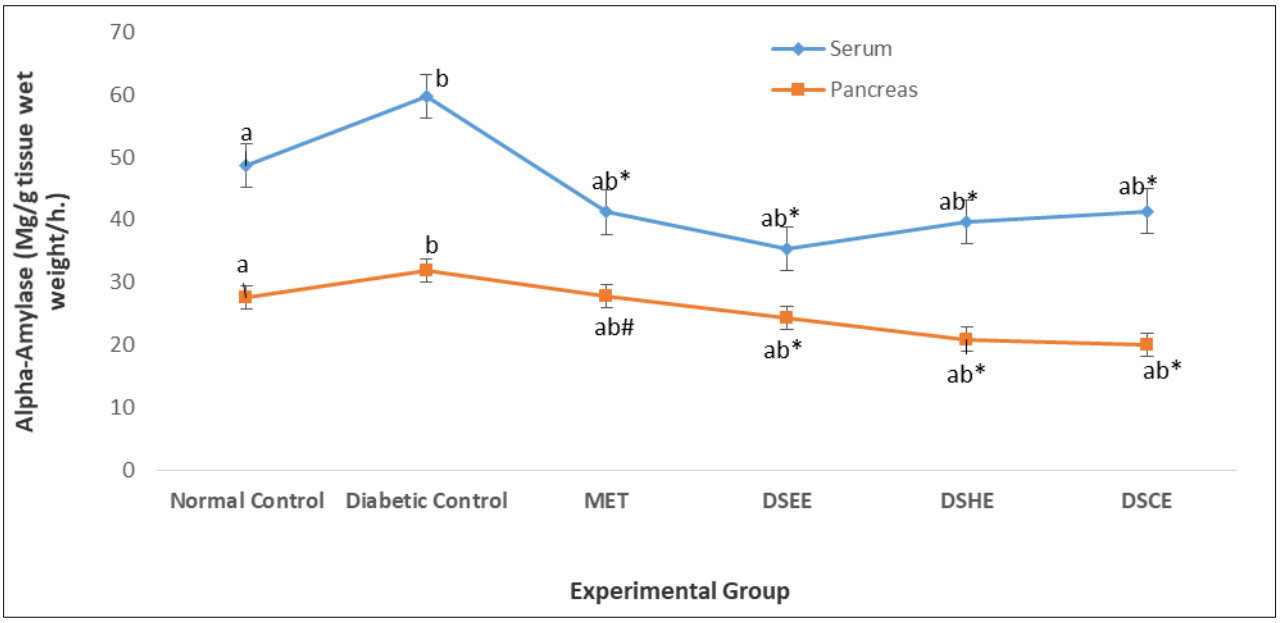


Values are expressed as mean± SEM. ANOVA followed by LSD's multiple range tests. (n=5). Relative to control (Pre DM-Induction) and negative control (DM induced, untreated) groups, Bars of same colour not sharing a common symbol (* or #) and/or alphabet (a or b) differ significantly at $p < 0.05$, insignificantly at $p > 0.05$.

Key: NC = Normal Control, DC = Diabetic Control, MET = Metformin (50 mg/kg), DSEE = *Deterium senegalense* bark ethyl acetate extract (250 mg/kg), DSHE = *Deterium senegalense* bark n-hexene extract (250 mg/kg), DSCE = *D. senegalense* bark Chloroform extract (250 mg/kg). *: statistically significant, #: Insignificant

Figure 1 Comparative Effect of *D. senegalense* Bark Fractions on Blood Glucose in Streptozotocin Induced Diabetic Wistar Rats

In long-standing antidiabetic test, the blood glucose level was significantly ($p < 0.05$) elevated in disease (diabetic) alone rats when compared to normal group due to the induction of diabetes. But administration of *D. senegalense* bark *ethyl acetate extract* (*DSEE*), *D. senegalense* bark *n-hexene extract*, and *D. senegalense* bark Chloroform extract (250mg/kg) (*DSHE*), and metformin (*MET*) (50mg/kg) respectively in experimental animals significantly ($p < 0.05$) decreased the blood glucose concentrations when compared to the diabetic control group as the treatment progressed.

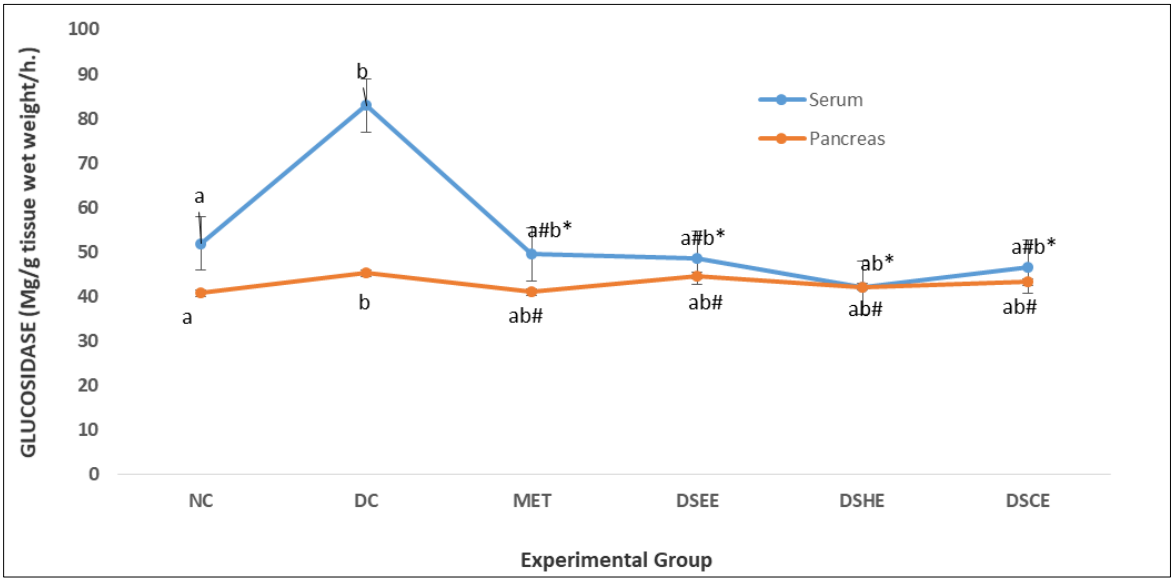


Values are expressed as mean± SEM. ANOVA followed by LSD's multiple range tests. (n=5). Relative to control (Pre DM Induction) and negative control (DM induced, untreated) groups, Line graph nodes of same colour (serum or pancreas) not sharing a common symbol (* or #) and/or alphabet (a or b) differ significantly at $p < 0.05$, insignificantly at $p > 0.05$ compared with Control (NC) and diabetic control (DC) groups.

Key: NC = Normal Control, DC = Diabetic Control, MET = Metformin (50 mg/kg), DSEE = *D. senegalense* bark ethyl acetate extract (250 mg/kg), DSHE = *Deterium senegalense* bark n-hexene extract (250 mg/kg), DSCE = *D. senegalense* bark Chloroform extract (250 mg/kg)

Figure 2 Effect of *D. senegalense* Bark Fractions on Glucose Digesting Enzyme; Serum and Pancreatic α-Amylase

In diabetic rats, a significant increase was observed in antioxidant activities of α-amylase The administration of chloroform, Hexane and Ethyl acetate fractions from the methanol bark extract of *D. senegalense* at a dose of 250 mg/kg and metformin (50 mg/kg) significantly decreases the activity of the enzyme's ability on the pancreas with the most potential being shown by the ethyl acetate extract group (Group 4).



Values are expressed as mean± SEM. ANOVA followed by LSD's multiple range tests. (n=5). Relative to control (Pre DM Induction) and negative control (DM induced, untreated) groups, Line graph nodes of same colour (serum or pancreas) not sharing a common symbol (* or #) and/or alphabet (a or b) differ significantly at $p < 0.05$, insignificantly at $p > 0.05$ compared with Control (NC) and Diabetic control (DC) groups.

Key: NC = Normal Control, DC = Diabetic Control, MET = Metformin (50 mg/kg), DSEE = *Deterium senegalense* bark ethyl acetate extract (250 mg/kg), DSHE = *Deterium senegalense* bark n-hexene extract (250 mg/kg), DSCE = *D. senegalense* bark Chloroform extract (250 mg/kg)

Figure 3 Effect of *D. senegalense* Bark Fractions on α-Glucosidases

Figure 3 The effect of various fractions of *DS* extract on **α-glucosidase** in streptozotocin-induced diabetic Wistar rats

In diabetic rats, a significant increase was observed in antioxidant activities of α-glucosidases The administration of chloroform, Hexane and Ethyl acetate fractions from the methanol bark extract of *D. senegalense* at a dose of 250 mg/kg and metformin (50 mg/kg) significantly decreases the activity of the enzyme's ability on the pancreas with the most potential being shown by the ethyl acetate extract group (Group 4)

Table 1 Major Peak Chemical Constituents of Methanolic *D. senegalensisas* Stem Extract Identified by GC-MS

s/no	Retention Time (RT)	Compounds	Molecular Formulae	Molecular Weight (g/mol)	Qual	Peak Area (%)
1	14.859	1,2,3,4-Tetradecanetetrol; Methyl 6-methyl heptanoate, Octanoic acid; 8-hydroxyoctanoate	C14H30O4; C9H18O2; C9H18O3	262.39; 158.24; 174.24	14 12 12	13.46
2	23.941	D-Fucose; Thiazole; 4-Ethoxy-2-butanone	C6H12O5; C3H3NS; C6H12O2	164.16; 85.13; 116.16	35 30 25	10.68
3	24.486	D-Fucose; alpha -L-Galactopyranoside; methy l 6-deoxy-Heptanoic acid	C6H12O5; C7H14O6; C15H15N7O2	164.16; 194.18; 325.33	43 42 38	2.03
4	24.630	alpha -L-Galactopyranoside; methyl 6-deoxy-Heptanoic acid; o-Acetyl-L-serine	C7H14O6; C15H15N7O2; C5H9NO4	194.18; 325.33; 147.13	40 38 25	1.23
5	24.712	D-Fucose; Pentanoic acid; 3-methyl-Heptanoic acid	C6H12O5; C5H10O; C8H16O2	164.16; 102.1317; 144.21	43 38 32	0.83
6	24.740	alpha -L-Galactopyranoside; methyl 6-deoxy-Octano4. ic acid; 4,5-dihydro-2-methyl-	C7H14O6; C9H16O2; C12H20N2O12	194.18; 156.22; 384.29	33 27 25	0.42
7	24.863	2-Deoxy-D-glucose; alpha -L-Galactopyranoside; methyl 6-deoxy-Heptanoic acid	C6H12O5; C7H14O6; C15H15N7O2;	164.16; 194.18; 325.33	42 40 23	1.77
8	24.885	alpha -L-Galactopyranoside; methyl 6-deoxy-D-Fucose Inositol, 1-deoxy-	C7H14O6; C6H12O5; C6H11O8P	194.18; 164.16; 242.12	50 43 33	0.46
9	24.930	D-Fucose alpha -L-Galactopyranoside, methyl 6-deoxy- Thiazole, 4,5-dihydro-2-methyl-	C6H12O5; C6H10O2	114.14; 164.16	43 40 38	0.47
10	27.283	6-Hepten-3-ol 11-(2-Cyclopenten-1-yl)undecanoic Acid Methyl 3-butynoate	C7H14O	114.19	17	15.53
11	27.406	3-Ethyl-3-heptanol 2-Furanmethanol; 5-ethenyltetrahyd ro-.alpha.,.alpha.,5-trimethyl-, cis-cis-1-Methyl-2-(2'-propenyl)cyclopropane	C9H20O; C12H20O3;	144.25; 212.28;	16 16	35.30

12	27.920	4-Heptenoic acid, methyl ester,(E)- 8-Nonynoic acid, methyl ester Butanamide, 3,N-dihydroxy-	C8H14O2; C4H9NO3	142.20; 119.12	32 23 12	10.76
13	35.281	3-Methyl-2-(2-oxopropyl)furan; 4-Methyl-1-heptyn-3-ol Dichloroacetic acid; 2,2-dimethylpropyl ester	C8H10O2; C6H10O3; C5H11NO2	138.16; 130.14; 117.15	22 14 14	19.72
14	38.086	Dodecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester Decane, 1-(ethenyloxy)- 2-Piperidinone, N-[4-bromo-n-butyl]-	C12H24O2; C23H46O4; C9H16BrNO	200.32; 386.6; 234.13	43 30 27	1.96
15	38.157	Dodecyl nonyl ether; Tridecane	C21H44O; C13H28	312.6; C13H28	18 14	0.31
16	38.519	Docosanoic acid; nonyl ester 3-Butenamide 2-Butyn-1-ol, 4-methoxy-	C22H44O2; C11H22O2; C5H8O2	340.6; 186.29; 100.12	11 9 9	-15.40

Phytochemical analysis of methanol bark extract of *Deterium senegalense*. Fri Apr 08 14:21:41 2022

4. Discussion

In this study, the chronic *in vivo* study was designed to examine the long-term consequences of methanol extract against streptozocin induced diabetes in Wistar rats. The blood glucose range in experimental animals was assessed every 7-day interval for the investigation period to test the ability of the *D. senegalense* extract to clear glucose from blood in diabetic wistar rats. This study confirms a significant rise in blood glucose range observed in diabetic control animals throughout the study due to the destruction of β-cells of pancreas which may have impaired the insulin secretion (Figure 2). However, in animal groups treated with *D. senegalense* fractionate, blood glucose was significantly reduced, with the ethyl acetate extract treated rats showing more anti-diabetic effects as shown in figure 2. This clearly indicates the potential of the *D. senegalense* extract in bringing about hypoglycemia. This discovery demonstrates anti-diabetic action similar to that of previously investigated antidiabetic plants.

Inactivation of carbohydrate-hydrolyzing enzymes such as alpha-amylase and alpha-glucosidase enzymes is one of the innovative therapeutic methods for the treatment of diabetes mellitus to counter GIT glucose absorption and thus to reduce postprandial hyperglycemia and its problems [14]. In the present study, The result in figure 3 and 4 of this study, *D. senegalense* extract exhibited significant α-glucosidase and α-amylase inhibitory properties indicating its usefulness in the reduction of postprandial glucose, but still, it is not clearly understood whether the inactivation of α-amylase enzyme and α-glucosidase enzyme by *D. senegalense* extract is due to competitive or non-competitive inhibition mechanisms.

A similar findings has also been confirm by Ossai *et al.* [15] whose report confirms the hypoglycemic property of Nephrolepis undulate leaf extract which was able to decrease the activities of alpha(s) amylase/glucosidase in digesting carbohydrate. The rate of inactivation of the alpha-glucosidase enzyme, however was similar to that of metformin, the standard reference drug used in the analysis, but the rate of inactivation of alpha-amylase was lower than that of the standard drug [15] This shows that *D. senegalense* extract is a potent inhibitor of α-glucosidase with less potent inhibitory property versus α-amylase (Figure 2 and figure 3). The α-glucosidase along with α-amylase enzyme inhibitory properties of *D. senegalense* extract can regarded to be a productive approach for the prevention of diabetes mellitus by declining the uptake of glucose into the blood. If the rate of absorption of glucose from the GIT into the blood circulation is decreased by inactivating carbohydrate hydrolysis, severe post-meal hyperglycemia typically experienced by patients with diabetes may be controlled [14].

In the present investigation, the effects of *D. senegalense* extracts on serum glucose in STZ-induced diabetic rats dramatically raised blood glucose in the diabetic control group. Up to seven days into treatment with metformin, the conventional medication, blood glucose levels significantly decreased. As a result, following 5 days of treatment for the current investigation, the metformin-treated group's glucose levels fell significantly. Albeit, blood glucose levels increased significantly in rats given a 250 mg/kg dosage of the *D. senegalense* ethyl acetate extract before beginning to

decline 3–4 days post treatment. A substantial decrease in blood sugar level was noted in the tested groups when compared with metformin treated and control groups.

Current study was also designed to investigate the phytochemical profile of ethanolic stem extract of *D. senegalense* by GC-MS. The choice of the extracting solvent (ethanol) reflected how the local communities within the study area used its concoction in traditional treatment of aliments using the plant. According to studies by Abuzeid et al., [16] claimed that an extract from this plant is used to treat diabetes, the use of this plant for traditional medicine by the people also indicated that the plant contains certain bioactive chemicals [16]. This was one of the driving forces behind the investigation into the real chemical composition of the extract, giving the need for the extraction of *D. senegalense* stem, which was subsequently used to screen for phytochemicals and assess hypoglycemic effects.

Its phytochemical analysis was equally carried out, and the result indicates the presence of a variety of phytoconstituents in the extract. These classes of chemical compounds are known to exert pharmacological effect more especially on the vital organs of the body [17, 18]. Although compared to some reports, the phytochemical screening of the leaves of *D. senegalense* revealed the presence of a variety of secondary metabolites, including tannins (Idris, 2014), flavonoids, saponins [19], alkaloids, glycosides, steroids [20].The presence of flavonoids indicate that *D. senegalensis* has antioxidant and anti-diabetic activities, and the alkaloid too can be applied in the treatment of some ailment.

3-Ethyl-3-heptanol, with a retention time (RT) of 27.406 minutes and a percentage peak area of 35.30 %, was the highest notable compound from the qualitative test result of the ethanolic stem bark extract of *D. senegalensis* (table 2). It was followed by 3-Methyl-2-(2-oxopropyl) furan, with RT and percentage peak areas of 38.519 minutes and 19.72 % respectively. With RT and percentage peak areas of 38.519 minutes, -15.40 %, and 38.157 minutes, 0.31 percent, respectively, and those with rising percentage availability of 15.53 percent, docosanoic acid nonyl ester and dodecyl nonyl ether were the least detected. Retention time for 6-Hepten-3-ol, 11-(2-Cyclopenten-1-yl) undecanoic is 27.283 minutes. Next to them in availability was 1, 2, 3, 4-Tetradecanetetrol (14.859 minutes), D-Fucose, Thiazole, 4, 5-dihydro-2-methyl-4-Ethoxy-2-butanone; (23.941 minutes), 2-Deoxy-D-glucose .alpha.-L-Galactopyranoside, methy l 6-deoxy-Heptanoic acid; (24.863 minutes).

The molecular weight of the observed compounds ranged from low to high with carbon skeleton of between C3 and C20 in both cyclic and aliphatic nature. The presence of these high RT valued constituents is suggestive of the attendance of Phenols and Tannins, and might have contributed hugely to the antidiabetic effects of *D. senegalense*, especially as observed with 250 mg/kg extract treatments, a characteristic property reportedly traceable to the possession of insulin-like effects or stimulation of insulin secretion by *D. senegalense* [21], the capacity of *D. senegalense* to prevent β-cells impairment through free radical scavenging [22], the tendence of *D. senegalense* to enhance β-cells propagation and restoration [23], as well as their roles in reducing carbohydrate absorption by impeding α-amylase and α-glucosidase activated [24].

In the phytochemistry investigation, the compound 3-Methyl-2-(2-oxopropyl) furan 4-Methyl-1-heptyn-3-ol Dichloracetic acid, 2, 2-dimethylpropyl ester was also commonly noted. This substance has an area prevalence of 19.72 percent (table 2), which is a sign of flavonoid and polyphenol functioning. By enhancing insulin release, GLUT-4 expression and translocation, and pancreatic -cell GLUT-2 expression, flavonoids and polyphenols have been proven to have antidiabetic characteristics [25, 26]. The ability of the liver, adipose tissues, and muscles to absorb glucose can ultimately be improved via each of these mechanisms [27].

Flavonoids also slow down gastric emptying, boost calcium ion absorption, block -glycosidase and -amylase, diminish aldose reductase, and regenerate pancreatic beta cells [28, 29]. As a result, the findings of the current study indicate that diabetic rats' fasting plasma insulin levels have significantly decreased. These results are consistent with those reported of type 2 DM in rats that was caused by nicotinamide and streptozotocin [30]. The results of the current investigation show that, at least in comparison to metformin administration, diabetic rats treated with *D. senegalense* had significantly higher insulin concentrations and lower blood glucose levels. This hypoglycemic action of *D. senegalense* may be due to its activity in reestablishing the physical state of the cell's plasma membrane and its associated processes, including glucose transport, which is largely under insulin control [31]. Moreover, the antioxidant property of *D. senegalense* might have a role in increasing insulin levels by protecting the β-cells of the pancreas against oxidative stress-induced cellular injury [32].

5. Conclusion

The findings from current study suggest that fractions of *D. senegalense* extract has anti-diabetic potential, and that the hypoglycaemic impact of these fractions could be mediated via blocking glucose hydrolyzing enzymes; having in vivo anti-diabetic activity. Compared to the normal control, there was a substantial decrease in the blood sugar, α-Amylase and α-Glycosidase levels in the *D. senegalense* treatment groups, with the most hypoglycaemic potential being shown by the ethyl acetate extract group. We recommend further research to corroborate, isolate and estimate the specific components present in *D. senegalense* extract that may be responsible for these observed anti-diabetic properties.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

Statement of ethical approval

All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. Also, all procedures performed in studies involving animals were in accordance with the ethical standards of the institution or practice at which the studies were conducted.

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