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# Hypoglycemic, Hypolipidemic and Antioxidant Potentials of Aqueous and Ethanolic Leaf Extracts of *Anacardium occidentale* in Alloxan Induced Type I Diabetic Rat Model

**Olusola Olalekan Elekofehinti[1,2*], Richard Oseh Osehodion[1], Tolulope Tosin Adeyelu[1], Tomisin Happy Ogunwa[1,2], Isaac Olatunde[1], Omosigho Aiwuyo[2] and Oluwamodupe Cecilia Ejelonu[1,2]**

*[1]Department of Biochemistry, Adekunle Ajasin University, Akungba, Akoko, Ondo State, Nigeria.*
*[2]Centre for Biocomputing and Drug Development, Adekunle Ajasin University, Akungba-Akoko, Nigeria.*

***Authors' contributions***

*This work was carried out in collaboration between all authors. Author OOE designed the study and wrote the protocol and managed the experimental process. Author OCE wrote the first draft of the manuscript and managed the literature searches, while authors TTA, THO, IO and OA performed the analyses of the study both animal and spectroscopy analysis. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aim:** The current study investigated the hypoglycemic, antioxidant and hypolipidemic effects of the aqueous and ethanolic leaf extracts of *Anarcardium occidentale* in alloxan-induced diabetic rats.
**Study Design:** *In vivo* experiment.
**Place and Duration of Study:** Department of Biochemistry, Adekunle Ajasin University, Akungba-Akoko, Ondo State, Nigeria, between Oct 2011 and Jan 2012.
**Methodology:** Diabetes was induced in albino rats by the administration of alloxan (150 mg/kg

**Corresponding author: E-mail: sola_eleko@yahoo.com;*

b.w.) intraperitoneally. Aqueous and ethanolic extracts of *A. occidentale* (200 mg/kg b.w.) were administered by oral gavage once a day for a period of 21 days. The effect of the extracts on blood glucose, lipids, total protein, liver marker enzymes and also on enzymatic antioxidants of defence systems such as superoxide dismutase (SOD), catalase (CAT), enzyme activities, in liver and pancreas were studied.

**Results:** Both aqeous and ethanolic extracts of *A. occidentale* reduced the blood glucose, total cholesterol (TC), triglycerides (TG) levels, total protein and activity of alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP) in alloxan-diabetic rats. The extracts also significantly mitigated the increase in malonyldialdehyde (MDA) level, and increased SOD and CAT activities in both liver and pancreas. The levels of high-density lipoprotein (HDL) were significantly increased in *A. occidentale* treated diabetic rats in comparison with control group. Our findings suggest that both extracts of *A. occidentale* prevented the alloxan-induced hyperglycemia and increased MDA levels. These effects could be attributed to the presence of bioactive phytochemicals present in these extracts.

**Conclusion:** These results suggest that *A. occidentale* extracts possess hypoglycemic, hypolipidemic and antioxidant properties.

*Keywords: Diabetes; Anacardium occidentale; phytochemical; hypolipidemic; antioxidant.*

## 1. INTRODUCTION

Diabetes Mellitus (DM) is a world health issue and a global leading cause of death. About 220 million people worldwide are suffering from diabetes and the number of people diagnosed with diabetes would have doubled by 2030 [1-4]. DM is a metabolic disorder of multiple etiologies characterized by chronic hyperglycemia leading to disturbances of carbohydrate, fat, and protein metabolism caused by defects in insulin secretion and/or insulin action [5,6].

There are two types of this disease condition which are type 1 (a multifactorial autoimmune disease, in which susceptibility is determined by a combination of genetic and environmental factors [7,8], and type 2 (characterized by the combination of insulin resistance and a compensatory response to inadequate insulin secretion) which may lead to hyperglycemia [9-11]. Hyperglycemia has been reported to induce oxidative stress in diabetes by override of the electron transport chain leading to the overproduction of superoxide anions, which cause potential damage to varieties of tissues [2,12-14]. Also, hyperglycemia results in autooxidation of glucose in the presence of a transition metal to generate reactive oxygen species (ROS) during the process of glycation [15,16].

Management of diabetes using conventional drugs poses serious problems like hypoglycemia, drug-resistance, dropsy and weight gain [17]. Alternative approaches especially from natural sources appear to be the way out [18].

*Anacardium occidentale*, also known as cashew, is a tropical evergreen plant which produced cashew nut and apple. It belongs to the family of Anacardiacease and it originated from Brazil [19]. *A. occidentale* has been traditionally used for the treatment of various ailments such as diabetes, diarrhea, malaria and yellow fever [20], weakness, urinary disorder, bronchitis, impotence and syphilis-related skin disorders [21]. The antihyperglycemic and antihyperlipidemic activities of the bark, nut and root of *A. occidentale* has been reported [22].

The antiperoxidative, radical scavenging and antioxidant capacities of *A. occidentale in vitro* have been documented [23]. The effect of methanolic leaf extract in streptozotocin induced diabetic rats has also been reported. The current study is therefore aimed at investigating the effect of aqueous and ethanolic extract of leaf of *A. occidentale in* alloxan induced diabetic rats.

## 2. MATERIALS AND METHODS

### 2.1 Chemicals

Alloxan was purchased from Sigma (Sigma-Aldrich, Germany), while thiobarbituric acid was purchased from Fluka (Buchs, Switzerland). Randox kits were purchased from Randox Laboratories Limited, UK. The other reagents used for the execution of the experiment were of analytical grade.

### 2.2 Plant Materials

The leaves of *A. occidentale* were collected from Adekunle Ajasin University, Akungba Akoko

horticultural garden, identified and authenticated at the herbarium of Plant Science and Forestry Department, Ekiti State University, Ado Ekiti, Nigeria. Fresh leaves were washed, shade-dried and ground to powder. The powder obtained (1 kg) was macerated in 3 litres of ethanol for 72 h at room temperature. The filtrate was concentrated under reduced pressure at 40℃ until extraction solvent was completely removed. A green soluble crude residue was obtained (about 64 g, 6.4% w/w). Sterile water was used to dissolve the extract.

## 2.3 Animals

Albino rats with average weight of 132±25 g were obtained from PRIMRAT, University College Hospital, Ibadan, Nigeria. They were divided into four groups of five animals each, allowed to acclimatize for two weeks and were housed in clean cage and maintained under standard laboratory conditions. The principles of laboratory Animal Care (Public Health Services, 1986) were followed throughout the duration of the experiment.

## 2.4 Experimental Procedure

Diabetes was induced through a single intraperitoneal injection of a freshly prepared alloxan (Sigma-Aldrich, Germany) solution in normal saline at a dose of 150 mg/kg body weight. Since the injection of alloxan can provoke fatal hypoglycemia due to a reactive massive release of pancreatic insulin, the rats were also orally given 5–10 ml of a 20% glucose solution after 6 h. The animals were then kept with free access to 5% glucose solution for the next 24 h to prevent severe hypoglycemia. Two weeks later, the rats with moderate diabetes having glycosuria and hyperglycemia (i.e. with blood glucose levels of 200–300 mg/dl) were chosen for the experiments. The rats (n = 20) were divided equally into 4 groups. Group I served as normal control, and were given 2 ml saline by gavage, group II served as diabetic control, group III were diabetic rats treated with aqueous extract of *A. occidentale* (200 mg/kg) while group IX were diabetic rats treated with ethanolic extract of *A. occidentale* (200 mg/kg). The treatment was for 21 days after which the rats were weighed and sacrificed by decapitation. Their blood was collected into clean dry beakers for serum preparation and the serum was prepared as previously described [24]. This was used for the determination of malondialdehyde (MDA), catalase (CAT) and superoxide dismutase (SOD). Glucose level was estimated using glucose oxidase peroxidase reactive strips and a glucometer. Fasting blood glucose was estimated every 2 days till day 21. The tissues (liver and pancreas) were removed into 0.25 M ice cold sucrose solution in a ratio of 1:5 w/v.

## 2.5 Biochemical Parameters

Using the supernatant of the centrifuged homogenate of the liver and pancreas tissues, the SOD and CAT levels were determined according to the method described by Sun and Zigman [25] and Aebi [26] respectively; whereas, the level of lipid peroxidation was determined as described by Okhawa et al. [27].

The serum levels of total cholesterol (TC), triglyceride (TG) and high density lipoprotein (HDL) were assayed by Randox commercial kit (United Kingdom).

## 2.6 Statistics Analysis

The data are expressed as mean± S.E.M (standard error mean). The differences among groups were analysis by the one-way analysis of variances (ANOVA). Inter-group comparison was done by using the Duncan multiple tests (DMRT), with 95% confidence interval. The SPSS 11.0 (SPSS Inc, Chicago, USA), was used for the analysis.

# 3. RESULTS

## 3.1 Effect of Aqueous and Ethanolic Extracts of *A. occidentale* on Blood Glucose

Administration of alloxan led to a significant increase in blood glucose levels in diabetics control group when compared to normal control (Table 1), and this was maintained over a period of three weeks. Administration of both aqueous and ethanolic extracts (200 mg/kg) of *A. occidentale* significantly ($P<0.05$) reduced blood glucose when compared with diabetic control. However, both extracts could not restore blood glucose to normal, at the tested dosage.

## 3.2 Effect of Aqueous and Ethanolic Extracts of *A. occidentale* on Total Protein (TP) of Alloxan Induced Diabetic Rats

As shown in Table 2, there was a significant decrease ($P<0.05$) in total protein level in the

serum, liver and pancreas of diabetic group when compared with the control. Treatment with 200mg/kg of both aqueous and ethanolic extracts of *A. occidental* increased the total protein significantly leaf when compared to diabetic control group (P<0.05). The level of total protein in ethanolic extract treated group was found to be higher than control at the tested dose.

### 3.3 Effect of Aqueous and Ethanolic Leaf Extracts of *A. occidentale* on AST, ALT and ALP in Serum of Alloxan Induced Diabetic Rats

From Table 3, a significant increase (P<0.05) in ALT, AST and ALP activity in serum of diabetic control when compared with treated groups was observed. At the tested dose, aqueous extract was able to reduced AST activity in serum below normal control level. Also, it was found that both treated groups reduced the elevated activity of AST, ALT and ALP in serum close to normal when compared with diabetic control (P<0.05).

### 3.4 Effect of Aqueous and Ethanolic Leaf Extracts of *A. occidentale* on Lipid Profile of Diabetic Rats

Alloxan administration increased significantly (P<0.05) total cholesterol and triacylglycerol concentration and reduced HDL level in diabetic control group when compared with normal control (Table 4). From our result, it was observed that on administration of both extract, there was significant decrease (P<0.05) in cholesterol and triglyceride level in treated groups when compared with diabetic control. Also, HDL concentration significant increase (P<0.05) in treated group when compared with diabetic control.

**Table 1. Effect of oral administration of aqueous and ethanolic extracts of *A. occidentale* on serum glucose of diabetic rats**

| Groups | Serum glucose (mmol/dl) |
|---|---|
| Control | 5.47±0.18 |
| Diabetic control | 8.81±0.16[a] |
| Alloxan + A.A.O (200 mg/kg) | 4.82±0.37[b] |
| Alloxan+ E.A.O (200 mg/kg) | 4.88+0.19[b] |

*Result is express as Mean±S.E.M (n=5). [a] Represent significant difference from control (P<0.05). [b] Represent significant difference from diabetic control (P<0.05). A.A.O: Aqueous extract of A. occidentale, E.A.O: Ethanolic extract of A. occidentale*

### 3.5 Effect of Aqueous and Ethanolic Leaf Extracts of *A. occidentale* on Lipid Peroxidation of Diabetic Rats

As shown in Table 5, there was a significant increase (P<0.05) in serum, liver and pancreas MDA levels in diabetic control group when compared with normal control (P<0.05). Both aqueous and ethanolic extracts treated groups restored MDA level to normal level. The level of serum MDA was lower in aqueous extract treated group than that of normal control while ethanolic extract treated group restored MDA concentration in the liver to that of normal control.

**Table 2. Effect of oral administration of Aqueous and Ethanolic extracts of *A. occidentale* on the Total protein concentration of diabetic rats**

| Group | Serum(mg/dl) | Liver(mg/dl) | Pancreas(mg/dl) |
|---|---|---|---|
| Control | 142.03±8.95 | 162.93±10.44 | 82.65±7.10 |
| Diabetic control | 94.52±7.65[a] | 88.83±15.69[a] | 39.90±3.38[a] |
| Alloxan + AAO (200 mg/kg) | 128.13±6.61[a,b] | 152.48±4.80[b] | 78.85±4.93[b] |
| Alloxan + EAO (200 mg/kg) | 146.68±10.41[b] | 139.18±7.25[a,b] | 59.85±4.55[a,b] |

*Result is express as Mean±S.E.M (n=5). [a] Represent significant difference from control (P<0.05). [b] Represent significant difference from diabetic control (P<0.05). A.A.O: Aqueous extract of A. occidentale. E.A.O: Ethanolic extract of A. occidentale*

**Table 3. Effect of Aqueous and Ethanolic leaf extracts of *A. occidentale* on AST, ALT and ALP in serum of alloxan induced diabetic rats**

| Group | ALT(mmol/l) | AST(mmol/l) | ALP(mmol/l) |
|---|---|---|---|
| Control | 8.68±1.31 | 13.82±0.86 | 134.0±2.27 |
| Diabetic control | 22.36±1.49[a] | 30.65±1.55[a] | 169.74±1.81[a] |
| Alloxan + AAO (200 mg/kg) | 9.87±0.81[b] | 11.97±1.73[b] | 134.23±10.30[b] |
| Alloxan + EAO (200 mg/kg) | 11.18±1.45[b] | 12.10±1.30[b] | 141.58±2.20[b] |

*Result is express as Mean±S.E.M (n=5). [a] Represent significant difference from control (P<0.05). [b] Represent significant difference from diabetic control (P<0.05), A.A.O: Aqueous extract of A. occidentale, E.A.O: Ethanolic extract of A. occidentale*

**Table 4. Effect of Aqueous and Ethanolic leaf extract of *A. occidentale* on lipid profile of diabetic rats**

| Group | TC(mg/dl) | TG(mg/dl) | $HDL_C$(mg/dl) |
|---|---|---|---|
| Control | 769.34±16.49 | 48.10±2.84 | 222.1±11.1 |
| Diabetic control | 1228±50.91[a] | 82.68±5.01[a] | 109.39±7.50[a] |
| Alloxan + AAO (200 mg/kg) | 749.26±17.65[b] | 45.43±8.60[b] | 235.10±7.47[b] |
| Alloxan + EAO (200 mg/kg) | 809.93±43.39[b] | 54.68±1.32[b] | 214.66±12.36[b] |

*Result is express as Mean±S.E.M (n=5 ). [a] Represent significant difference from control (P<0.05). [b] Represent significant difference from diabetic control (P<0.05). A.A.O: Aqueous extract of A. occidentale, E.A.O: Ethanolic extract of A. occidentale*

**Table 5. Effect of Aqueous and Ethanolic leaf extracts of *A. occidentale* on MDA of diabetic rats**

| | Serum (mmol/l) | Liver (mmol/mg protein) | Pancreas (mmol/mg protein) |
|---|---|---|---|
| Normal control | 15.86±1.70 | 28.18±3.52 | 8.08±2.25 |
| Diabetic control | 30.97±2.43[a] | 40.28±2.13[a] | 25.27±3.07[a] |
| Alloxan + AAO (200 mg/kg) | 13.43±2.57[b] | 31.67±2.42[b] | 14.15±3.41[b] |
| Alloxan + EAO (200 mg/kg) | 18.83±4.07[b] | 28.83±3.68[b] | 12.77±2.47[b] |

*Result is express as Mean±S.E.M (n=5). [a] Represent significant difference from control (P<0.05). [b] Represent significant difference from diabetic control (P<0.05). A.A.O: Aqueous extract of A. occidentale, E.A.O: Ethanolic extract of A. occidentale.*

**Table 6. Effect of Aqueous and Ethanolic leaf extracts of *A. occidentale* on CAT of diabetic rats**

| | Serum (mmol/l) | Liver (mmol/mg protein) | Pancreas (mmol/mg protein) |
|---|---|---|---|
| Normal control | 379.41±28.20 | 13.29±1.48 | 53.44±32.43 |
| Diabetic control | 114.91±40.92[a] | 7.34±0.95[a] | 16.27±2.60[a] |
| Alloxan + AAO (200mg/kg) | 120.66±11.0[a,b] | 11.81±2.91[b] | 35.60±18.04[a,b] |
| Alloxan + EAO (200mg/kg) | 132.16±5.75[a,b] | 13.79±4.51[b] | 21.22±4.88[a,b] |

*Result is express as Mean±S.E.M (n=5). [a] Represent significant difference from control (P<0.05). [b] Represent significant difference from diabetic control (P<0.05). A.A.O: Aqueous extract of A. occidentale, E.A.O: Ethanolic extract of A. occidentale*

**Table 7. Effect of aqueous and ethanolic leaf extract of *A. occidentale* on SOD of diabetic rats**

| | Serum (mmol/l) | Liver (mmol/mg protein) | Pancreas (mmol/mg protein) |
|---|---|---|---|
| Normal control | 0.54±0.03 | 0.142±0.06 | 0.06±0.02 |
| Diabetic control | 0.29±0.03a | 0.045±0.01a | 0.04±0.08a |
| Alloxan + AAO (200 mg/kg) | 0.42±0.05b | 0.083±0.07b | 0.05±0.03 |
| Alloxan + EAO (200 mg/kg) | 0.48±0.05b | 0.081±0.05b | 0.07±0.03b |

*Result is express as Mean±S.E.M (n=5). [a] Represent significant difference from control (P<0.05). [b] Represent significant difference from diabetic control (P<0.05). A.A.O: Aqueous extract of A. occidentale, E.A.O: Ethanolic extract of A. occidentale*

### 3.6 Effect of Aqueous and Ethanolic Leaf Extracts of *A. occidentale* on CAT and SOD Activities of Diabetic Rats

Tables 6 and 7 show the levels of the oxidative stress enzymes activities in serum, liver and pancreas respectively. CAT and SOD activity were significantly decreased in diabetic control group (P<0.05) when compared to normal control. Treatment with both aqueous and ethanolic extracts of *A. occidentale* increased significantly (P<0.05) the activity of CAT and SOD in serum, liver and pancreas though not to normal control level.

## 4. DISCUSSION

Diabetes mellitus is probably the world's largest growing metabolic disorder and as the knowledge on the heterogeneity of this disorder advanced, so is the need for more appropriate therapy [28]. The high cost of conventional medicines which is beyond the reach of most people in developing countries necessitates the need for alternative strategies in the management of diabetes. Medicinal plants are generally used worldwide for a range of diabetic complications and investigating such plants might provide a natural key to treatment rather than management of diabetes.

### 4.1 Effect of Aqueous and Ethanolic Extract of *A. occidentale* on Blood Glucose

Alloxan is a toxic analog of glucose that selectively destroys insulin secretory β-cells, thus impairing insulin secretion and function [29, 30]. The result of this study showed that alloxan administration induced hyperglycemia that was sustained for a period of 21 days. Treatment with both aqueous and ethanolic extracts of *A. occidentale* reversed the observed hyperglycemia in diabetic animals. The hypoglycemic effect could be due to the ability of bioactive phytochemicals in *A. occidentale* to directly stimulate insulin secretion in the remaining β-cells [31-34]. The plant extract may be acting through insulin-like extra- pancreatic mechanism such as stimulation of glucose utilization and the reduction of hepatic gluconeogenesis [34].

### 4.2 Effect of Aqueous and Ethanolic Extract of *A. occidentale* on Total Protein (TP) of Alloxan Induced Diabetic Rats

Insulin deficiency, caused by alloxan, diverts metabolic system from glucose utilization to excessive breaking down of tissue protein, in which the amino acids released during this process are used for gluconeogenesis, leading to the decrease of total protein level observed in this study [35,36]. As shown in this study, significant decrease in total protein was observed in diabetic rat which was reversed by treatment with aqueous and ethanolic extracts of *A. occidentale*. The ability of the plant extracts to restore the β-cell of the pancreas and also act as insulin-like extra pancreatic activities help in the stimulation and metabolism of glucose which in turn prevent the utilization of tissue protein for gluconeogenesis as seen in the current study [34].

### 4.3 Effect of Aqueous and Ethanolic Leaf Extract of *A. occidentale* on AST, ALT and ALP in Serum of Alloxan Induced Diabetic Rats

AST, ALT and ALP are important biomarkers used to indicate liver function and activities. Its elevation in the serum may indicate liver injury and sometimes muscles injury [37]. Diabetic condition can induced liver injury by oxidative damage cause by the release of destructive radicals leading to significant increase in serum AST, ALT and ALP in diabetic control rats, when compared with normal control groups [2,13]. The observed increase in AST, ALT and ALP activities in this study is due to the absence of insulin, leading to increased amino acid utilization, and this is responsible for the increase of gluconeogenesis and ketogenesis observed in the diabetic condition. The significant reduction of AST, ALT and ALP concentration in both aqueous and ethanolic leaf extracts of *A. occidentale* when compared with diabetic control is due to its antioxidative agents such as flavonoids, saponins and phenols [2,38,39] which have been reported to exhibit hepatoprotective effects. ALP functions as a marker enzyme for membrane integrity. The increase of ALP in the serum may indicate lipid peroxidation in cell membrane, which occur in diabetics condition hence the reduction of ALP by aqueous and ethanolic extracts of *A. occidentale* is an indication of antiperoxidative effect of the plant or plant composition [39].

### 4.4 Effect of Aqueous and Ethanolic Leaf Extracts of *A. occidentale* on Lipid Profile

The serum lipid levels of the *A. occidentale* treated diabetic rats were significantly reduced after 21 days of treatment as against that of untreated diabetic rats in this study. Diabetes-induced hyperlipidemia is attributable to excess mobilization of fat from the adipose tissue due to under-utilization of glucose [40]. In diabetic condition, the body switches its metabolic fuel from glucose to other metabolites such as stored fatty acids and proteins [35]. The increase in TC and TG as observed in this study could result from the shift in glucose utilization to persistent utilization of stored TG as metabolic fuel and the increase in cholesterol can lead to coronary heart disease condition and atherosclerosis [2,41]. The reversal of the diabetic state due to the administration of the both aqueous and ethanolic extracts may have increased the utilization of glucose, thereby inhibiting the mobilization of fat. Phytochemical compounds like phenols, tannins, alkaloids, steroids and saponins present in these extracts have been reported to exert anti-hyperlipidemic activity [42].

### 4.5 Effect of Aqueous and Ethanolic Leaf Extracts of *A. occidentale* on Lipid Peroxidation

Lipid peroxidation is a free radical induced process leading to oxidative deterioration of

polyunsaturated fatty acid present in biological membranes. Under normal condition, lipid peroxidation occurs but to a lower extent and it is found in low concentration in tissue and organs [43]. The elevation of lipid peroxidation in serum, which is mediated by tissue damage, has been considered as a feature of chronic diabetes and has been observed in developmental cases of both type 1 and 2 diabetes condition [44]. The level of MDA in serum, liver and pancreas is important as an excellent biomarkers for lipid peroxidation, indicating tissue injury [45]. The increase MDA level in diabetic rats totally agrees with the previous findings [43,45,46]. The significant decrease in MDA level in serum, liver and pancreas on administration of both extracts of *A. occidentale* when compared with diabetic control totally agrees with the findings of other researchers [47]. This decrease of MDA concentration in treated group may be attributed to the presence of some important free radical scavengers such as flavonoid, saponin and phenolic compounds that mop up the free radicals making them unreactive to membrane lipids [47,2].

### 4.6 Effect of Aqueous and Ethanolic Leaf Extracts of *A. occidentale* on Antioxidant Enzymes

This significant decrease in CAT and SOD activities in studied tissues can be attributed to the generation of free radicals in the biological system of diabetic rats [2]. Oxidative damage can occur from the imbalance between the free radical generation and antioxidant defense. These destructive oxidative radicals are retarded by a defensive mechanism in the biological system. This mechanism can be enzymatic and non enzymatic. Super oxide dismutase (SOD) and catalase (CAT) are examples of enzymatic defence mechanism, which detoxify these free radicals [48]. The significant decrease in SOD and CAT concentration in diabetic control may be due to a high amount of reactive oxygen species (ROS) that resulted from derangement of metabolism occasioned by insulin deficiency or inability of insulin receptors. The net effect is oxidative stress which may arise from an imbalance between ROS generation and endogenous SOD and CAT [19,49]. Hyperglycemia has been reported to cause protein glycation leading to loss of protein activity. Excessive ROS production also enhances loss of enzyme activity. These may be responsible for the decreased SOD and CAT activities observed in diabetic control group. The ability of aqueous and ethanolic extracts to increase CAT and SOD activity in diabetic rat could be as a result of the hypoglycemic as well as antioxidant effect of phenolic and other bioactive compounds in *A. occidentale* that help in scavenging free radicals and hence, preventing them from degenerate into other destructive oxygen species, thereby assisting the antioxidative enzymes to properly detoxify ROS and other free radicals. Other potential antioxidant found in *A. occidentale* that are believed to help in scavenging ROS and free radicals in order to prevent the oxidation of cell are flavonoids and ascorbic acids [50].

## 5. CONCLUSION

In conclusion, the results of the current study showed that aqueous and ethanolic leaf extracts of *A. occidentale* possessed antidiabetic, hypolipidemic and antiperoxidative properties. These effects could be attributed to the presence of bioactive phytochemicals present in the leaf. This confirmation justifies its use in ethnomedicine for the treatment of diabetes.

## CONSENT

It is not applicable.

## ETHICAL APPROVAL

All authors hereby declare that "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 appropriate ethics committee.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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