

Hypoglycaemic and Hypolipidemic Effects of *Treculia Africana* aqueous Leaves Extract in Alloxan Induced Diabetic Rats

Abstract

This study investigated the hypoglycaemic and hypolipidaemic effects of *Treculia Africana* plant used in Nigeria as medicinal plant. Diabetes mellitus was induced by a single dose intraperitoneal injection of alloxan 150mg/kg body weight. Twenty five (25) male albino rats were divided into five groups, five (5) rats per group; normal control, diabetic control and diabetic groups treated with aqueous leaves extract of 200,400 and 800mg/Kg body weight respectively for 21 days. The effects of the extract on some biochemical parameters were evaluated; fasting blood glucose level was assayed using glucose oxidase method, total cholesterol and HDL –cholesterol were assayed using enzymatic method while LDL-cholesterol was determined by Friedewald equation. The results showed that, extract significantly ($p<0.05$) decrease the elevated fasting blood glucose levels, total cholesterol, triglyceride and LDL- cholesterol when compared with the diabetic control rats. The extract also caused significant ($p<0.05$) increased in HDL –cholesterol and body weight when compared with diabetic control rats. Aqueous leave extract of *Treculia Africana* possess hypoglycemic effect and the most effective dose was 800mg/Kg body weight in amelioration of hyperglycaemia and most all toxicity effects of alloxan on lipid profile.

Key words: Hypoglycaemic, Hypolipidaemic, *Treculia Africana* plant

1.0 Introduction

Diabetes mellitus (DM) is a metabolic disease characterized by a persistent elevation of fasting blood glucose level (FBGL) above 200 mg/dl, due to insufficient or complete cessation of insulin synthesis or secretion and/or peripheral resistance to insulin action (Ortiz-Andrade et al., 2005). It is characterized by persistent hyperglycemia and disturbances in the metabolism of fuel compounds (Saidu et al., 2010). It occurs when pancreas cannot produce insulin (type 1 DM) or cannot produce enough of insulin or the body cannot effectively use the produced insulin for effective uptake of glucose to the target cells (type II DM) (Hajera et al., 2011). Lipid abnormalities, anemia, alteration of liver and kidney functional indices has been implemented as major risk factors to the progression of both microvascular and macrovascular diabetes complications (Canargo and Gross, 2014). Globally, as of 2013, an estimated 382 million people have diabetes worldwide, with type 2 diabetes making up about 90% of the cases. This is equal to 3.3% of the population, with equal rates in both women and men (Vos, et al., 2012). Ethnomedicinal plants might provide new oral hypoglycemic

36 compounds, which can counter the high cost of the current hypoglycemic medicines for many
37 rural populations in developing countries (Noor et al., 2008).

38 African breadfruit is a large, slow-growing, evergreen tree with a dense, spreading crown;
39 usually growing 15 - 30 metres tall but with some specimens up to 50 metres (Ruffo et al.,
40 200). Survey among herbalist and number of patients attending Diabetic clinics in the
41 University College hospital Ibadan revealed the ethno-medicinal hypoglycemic effect of
42 *Treculia Africana* (Oyelola et al., 2007). In Ghana, the root decoction is used as an
43 anthelmintic and febrifuge. Ethnomedically, it is used as a verbrifuge, vermifuge,
44 galactagogue and laxative (Ogbonnia et al.,2008). Herbal medicine is in used by about 60%
45 of the world population both in the developing and in the developed countries where modern
46 medicines are predominantly used (Richert et al., 1999). Ethno-medicinal anti-diabetic plants
47 might provide new oral hypoglycemic compounds, which can counter the high cost and poor
48 availability of the current medicines for many rural populations in developing countries
49 (Noor et al., 2008)

50 **2.0. METHODOLOGY**

51 **2.1. COLLECTION AND IDENTIFICATION OF PLANT MATERIALS**

52 *Treculia Africana* leaves was obtained from Umuidi community of Anambara State of
53 Nigeria. The sample was identified and authenticated by the Department of Science
54 Laboratory Technology, Federal Polytechnic Kaura Namoda, Zamfara State. Nigeria

55 **2.2. PREPARATION OF SAMPLES**

56 The samples were thoroughly washed to remove sand and the drained parts were air dried
57 later. The samples were grounded using wooden mortar and pestle until powder was obtained
58 to ensure homogeneity. 100g of the plant powder was soaked in 1000ml of boiled distilled
59 water and agitated intermittently for 24 hours. The solution was then filtered using filter
60 paper to obtained the aqueous extract which was then be allowed to dried in an oven dryer at
61 100°C to obtained the crude extract (Luka, 2013). The extract was stored in an air tight
62 container for further work, the required doses of 200mg, 400mg and 800mg/kg body weight
63 was obtained by reconstituting the stored extract using distilled water and administered
64 (Meraiyebu, 2014).

65 **2.3 Experimental Animals**

66 Twenty five (25) apparently healthy young male Wister albino rats weighing between 100 –
67 200 g were used for this study. The rats were kept at animals' house under normal
68 environmental conditions and maintained with free access to pelletized growers feed, and
69 access to water *ad libitum*. The animals were allowed to acclimatize for two weeks (14 days).

70 **2.4 Induction of Diabetes**

71 All rats, except the Normal Control Group were intraperitoneally injected with 150 mg/kg
72 body weight of the prepared alloxan. Seventy two hours (three days) after alloxan
73 administration, the animals were fasted overnight and diabetes was confirmed from the rats
74 by measuring their fasting blood glucose level with the aid of a single touch glucometer. Rats
75 that have fasting blood glucose level >7.0 mmol/l (126mg/dl) were considered diabetic and
76 included in the study (Kandur and Goyal, 2005).

77 **2.5. Experimental Design**

78 By the end of the seven days acclimatization period, the animals were randomly assigned into
79 five different groups of five rats each, designate as group A-E. Group A received water and
80 feed only and serve as positive control. Diabetes was induced in group B, C, D, and E. Group
81 B serve as negative control while group C to E corresponding to 200, 400 and 800 mg/kg
82 doses of the aqueous leave extract of *Treculia Africana* were administered orally. After four
83 weeks of treatment, different biochemical parameters were analyzed including estimation of
84 fasting blood sugar level, Lipid profile, Heamatoligical and liver function indices.

85 **2.5.0 Determination of Biochemical Parameters**

86 **2.5.1 Estimation of Serum Glucose Level**

87 Serum glucose was estimated by glucose oxidase/ peroxidase method using Randox kit
88 (Trinder, 1969)

89 **2.5.2 Procedure**

90 Test tubes were set up in triplicates and labelled blank, test and standard. 10µl of serum,
91 standard (5. 5 mmol/L) and distilled water were respectively pipetted in to the test tubes.

Each test tube is then followed by 1000 µl of the reagent. The tubes were mixed properly, incubated at 37°C for 10 minutes and the absorbance of standard and tests read against the blank at 500nm using spectrophotometer.

Calculation: The glucose concentration was calculated using the relation:

$$\text{Serum glucose (mmol/L)} = \frac{\text{Absorbance of Test}}{\text{Absorbance of Standard}} \times \text{conc of standard}$$

2.5.3 Estimation of Serum Total Cholesterol

Serum total cholesterol (TC) was estimated by enzymatic method using Randox kit (Allain et al., 1974).

Three test tubes were set up and labelled blank, test and standard. In to test tubes labelled test, standard and blank, 10 µl of serum, standard (200 mg/dl) and distilled water were respectively pipetted in to the test tubes. Each test tube is then followed by 1000 µl of the reagent as shown above. The test tubes were mixed, incubated at 37°C for 5 minutes and the absorbance of the standard and test were read against the blank at 500 nm against the reagent blank.

Calculation

Cholesterol concentration was obtained using the relation:

$$\text{Serum total cholesterol (mg/dl)} = \frac{\text{Absorbance of Test}}{\text{Absorbance of Standard}} \times \text{Conc of Standard}$$

2.5.4 Estimation of Serum HDL - C

This was done by enzymatic method of (Burstein et al., 1970) using Randox Kit. Into centrifuge tubes, 200 µl of serum and 500 µl of precipitant (0.55 mmol/L phosphotungstic acid and 25 mmol/l Magnesium Chloride) were added, mixed and allowed to stand for 10 minutes at room temperature. The tubes were centrifuged for 10 minutes at 4000 rpm. The supernatant was collected and used for the analysis. Three test tubes were then set up and

115 labeled blank, standard and test. The tubes were mixed and incubated for 5 minutes at 37⁰ C
116 and the absorbance of the samples and standard were measured against the reagent blank at
117 500nm.

118 **Calculation**

119 The HDL-C concentration was obtained from the relation:

$$120 \quad \text{Serum HDL-C (mg/dl)} = \frac{\text{Absorbance of Test}}{\text{Absorbance of Standard}} \times \text{Conc. of Standard}$$

121

122 **2.5.5 Estimation of Serum Triglyceride**

123 This was assayed by the method of (Tietz, 1990) using Randox Kit. The tubes were mixed
124 and incubated at 37°C for 5 minutes and the absorbance of the standard and tests were read at
125 500nm against the blank.

126 **Calculation:** The TG levels were calculated using the relation:

$$127 \quad \text{Serum TG (mg/dl)} = \frac{\text{Absorbance of Test}}{\text{Absorbance of Standard}} \times \text{Conc. of Standard}$$

128 **2.5.6 Estimation of Serum LDL – C**

129 This was calculated using Friedewald formula (Friedewald et al., 1972).

$$130 \quad \text{LDL - C (mg/dl)} = \text{TC} - (\text{HDL - C}) + \left(\frac{\text{TG}}{5} \right)$$

131 **2.5.7 Estimation of Serum VLDL – C**

132 This was calculated using Friedewald formula (Friedewald et al., 1972)

$$133 \quad \text{VLDL - C (mg/dl)} = \frac{\text{TG}}{5}$$

134 **3.0 RESULT AND DISCUSSION**

135 **3.1 Table (1) Effect of alloxan on fasting blood sugar levels and lipid profile in alloxan**
136 **induced diabetic albino rats**

	FBS (mg/dl)	TAG (mg/dl)	CHOLESTERO L (mg/dl)	HDL (mg/dl)	LDL (mg/dl)
Non diabetes control	61.33±2.9a	1.58 ± 0.3b	3.11±0.6c	1.75±0.4d	1.04±0.2e
Diabetes control	268.84±0.3a	4.86±0.3b	5.98±0.3c	1.37±0.3c	3.31±0.1c

137 Values are expressed as mean ± SD, n= 5 for each group, Mean values having different superscript letter in the
138 same column are significantly different at ($p<0.05$).
139

140 As shown in table 1, after induction of diabetes mellitus by alloxan, the serum glucose level
141 raised to about 268.33 mg/dl with significant increase levels of triacylglyceride (TAG),
142 cholesterol, and LDL- Cholesterol with significant decrease in HDL- Cholestrol level in all
143 diabetes induced groups.

144 Fasting blood glucose concentration which is the most routine biochemical marker in the
145 diagnosis of diabetes mellitus in clinical and experimental settings (Mayfeild, 1998) was
146 measured in this study. Table 1 revealed significant increased ($PC<0.05$) in fasting blood
147 glucose concentration, triacylglyceride (TAG), total cholesterol and low density lipoprotein
148 (LDL) cholesterol with significant ($P<0.05$) decreased in HDL- cholesterol in all alloxan
149 induced diabetes albino rats compared to non-diabetic control rats. Elevated value of fasting
150 blood glucose concentration (268.33 mg/dl) observed in diabetic rat is due to the toxic effect
151 of alloxan on islet beta cells of the pancreas (Ohno et al., 2000) through its ability to induce
152 reactive oxygen species (ROS) formation, resulting in the necrosis of the pancreas (Lenzen,
153 2008) and loss of capacity of the pancreas to secrete insulin (Zafar et al., 2009) leading to
154 hyperglycemia. Chronic exposure to hyperglycemia is the primary casual factor in the
155 pathogenesis of diabetic complications and cause changes in vascular tissue that promote
156 atherosclerosis (Rafiu and Lika, 2015). The elevated values for lipid profile parameters such
157 as triglyceride, LDL-cholesterol, and total cholesterol observed in the alloxan induced
158 diabetic rats could be partly due to increased intestinal biosynthesis of cholesterol (Luka et
159 al., 2013) because diabetes shifted the major site of cholesterologenesis from the liver to the
160 small intestine (Young et al., 1982) leading to hypercholesterolemia. Sever diabetes mellitus

due to insulin deficiency might be accompanied with a reduced LDL-receptor (Swami et al., 1996) resulting to high concentration of serum LDL cholesterol in diabetic subject.

3.2 Table (2) Effect of aqueous leaves extract of *Treculia africana* on fasting blood sugar levels in alloxan induced diabetic albino rats

Experimental groups	Fasting Blood Glucose levels (mg/dl)
Diabetic control	268.33 $\pm$ 16.8 ^{bcd}
Non-Diabetic control	61.43 $\pm$ 8.73 ^{acd}
Alloxan + 200mg/kg b.w of the <i>T. africana</i>	73.66 $\pm$ 5.77 ^{abd}
Alloxan + 400mg/kg b.w of the <i>T. africana</i>	66.01 $\pm$ 5.00 ^{abc}
Alloxan + 800mg/kg b.w of the <i>T. africana</i>	53.33 $\pm$ 5.50 ^{abcd}

Values are expressed as mean $\pm$ SD, n= 5 for each group, Mean values having different superscript letter are significantly different at ($p < 0.05$).

Table 2, Revealed that oral administration of high dose of aqueous leaves extract of *Treculia africana* 800mg/kg body weight for twenty one (21) days to the diabetic rats significantly ($p < 0.05$) decreased the elevated fasting blood sugar concentration compared with the diabetic control rats. Our finding was in line with the finding of (Ogbonnia, Odimegwu, & Enwuru, 2008) that's their finding stated that, aqueous ethanolic extracts of *Treculia africana* Decne was the most powerful in amelioration hyperglycemia. According to researchers at the Departments of Physiology and Biochemistry, College of Medical Sciences, University of Calabar, who conducted a study using a *Treculia africana* (breadfruit) seed diet on rats, found that it significantly lowered blood lipid levels and blood glucose levels in diabetic rats compared to rats fed on normal diet (Efeoye, 2013). Oral administration of high dose of aqueous ethanol extract of *Treculia africana* root bark (500mg/kg for 21days) to the diabetic rats ameliorated the diabetic complications by declined the glucose levels (Ogbonnia, et al., 2012) reflecting a restoration of the pancreatic β -cells activity (El-Desouki et al., 2015). Phytochemical screening revealed that, *Treculia Africana* was found to contain polyphenol and tannins (Ogbonnia et al., 2012; Osabor et al., 2009). Phenolic compounds might be useful medicinal food components and could contribute to manage both hyperglycemia and proper cellular redox status (Ali, 2013). Quercetin-3-O- glucoside, quercetin-3-O (-6''- malonyl glucoside) and kaempferol-3-O (-6''-malonyl glucoside) which are polyphenol compounds were reported to be responsible for hypoglyceamic activity (Luangpiom et al., 2013).

188 **3.3 Table (3) Effect of aqueous leaves extract of *Treculia africana* on serum lipid profile**
 189 **in alloxan induced diabetic albino rats**

Experimental groups	Total cholesterol (mg/dl)	TAG (mg/dl)	HDL- Cholesterol (mg/dl)	LDL- Cholesterol (mg/dl)
Diabetic control	5.86 ± 0.15 ^a	4.86 ± 0.15 ^b	1.37 ± 0.06 ^c	3.31 ± 0.72 ^d
Non- Diabetic control	3.11 ± 0.05 ^a	1.58 ± 0.50 ^b	1.75 ± 0.55 ^c	1.04 ± 0.55 ^d
Alloxan + 200mg/kg b.w. of the <i>T. africana</i>	3.18 ± 0.65 ^b	1.55 ± 0.66 ^c	2.2 ± 0.70 ^d	0.67 ± 0.65 ^e
Alloxan + 400mg/kg b.w. of the <i>T. africana</i>	3.02 ± 0.60 ^{ab}	1.56 ± 0.51 ^{bc}	1.95 ± 0.61 ^{cd}	0.84 ± 0.55 ^{db}
Alloxan + 800mg/kg b.w. of the <i>T. africana</i>	3.13 ± 0.55 ^{ac}	1.4 ± 0.62 ^{bd}	1.9 ± 0.90 ^{ad}	0.84 ± 0.66 ^{dc}

190 Values are expressed as mean ± SD, n= 5 for each group, Mean values having different superscript letter in the
 191 same column are significantly different at ($p < 0.05$).
 192

193 Table (3) revealed that oral administration of aqueous extract of *Treculia africana* at a doses
 194 of 200, 400 800 mg/kg body weight for 21days to diabetic rats resulted in significant
 195 ($p < 0.05$) reduction in total cholesterol, low density lipoprotein and triglyceride. These finding
 196 of the present study was in agreement with the finding of (Ogbonnia et al., 2008; Ogbonnia et
 197 al., 2011), this reduction in total plasma cholesterol, low density lipoprotein and triglyceride
 198 confirming the hypolipidaemic properties of *Treculia Africana*. This could be due to the
 199 presence of saponins that can inhibit taurocholate and deoxycholate absorption in a dose-
 200 dependent manner (Sheikhla, 2013). Phytochemical screening revealed that, *Treculia*
 201 *africana* was found to contain saponin (Ogbonnia et al., 2008). Oral administration of
 202 *Treculia africana* leave extract to the diabetic rats ameliorated the diabetic complications by
 203 declined the LDL-Cholesterol, total cholesterol and triglyceride levels reflecting a restoration

of the pancreatic β -cells activity (El-Desouki et al., 2015) to secrete insulin. Insulin is a potent activator of lipoprotein lipase and inhibits VLDL production by the liver as well as to promote the reduction of LDL-cholesterol concentration (Galland, et al., 2006). Thus, the effect of *Treculia africana* at reducing the LDL-cholesterol level of the diabetic rats may suggest the ability of the extract to increase the number of LDL receptors, with consequent reduction in LDL-cholesterol (Omega et al., 2011), this confirming the hypoglycemic and hypolipidaemic properties of *Treculia africana* leaves.

3.3.1. Conclusion

Aqueous leave extract of *Treculia Africana* possess hypoglycemic effect and the most effective dose was 800mg/Kg body weight in amelioration of hyperglycaemia and most all toxicity effects of alloxan on lipid profile and some liver biomarker enzymes.

REFERENCES

- Ali, A. M. (2013). Anti-Diabetic Potential Of Phenolic Compounds: A Review. *International Journal of Food Properties*, 16, 91–103.
- Allain, C., Poon, L., Chan, C., Richmond, W., & Fu, P. (1974). Enzymatic Determination of Total Serum Cholesterol. *J. Clinical Chemistry*, 20: 470, 20, 470.
- Burstein, M., Scholnick, H., & Morfin, R. (1970). Rapid Method for the Isolation of Lipoproteins from Human Serum by Precipitation with Polyanions. *J. Lipid Res*, 11, 583-595.
- Canargo, J., & Gross, J. (2014). Conditions Associated with Very low Values of Glycohemoglobin Measured by an HPLC Method. *Journal of Clinical Pathology*, 57: , 346-349.
- Efeooeye. (2013). *African breadfruit (Gbeere): Nature's antidote to sleeplessness, hypertension*. University of Calabar, Physiology and Biochemistry, College of Medical Sciences . Calabar: tribune.com.ng.
- El-Desouki, N. I., Aboulfotouh, B. M., Abdelmonaim, M. H., & El –Aama, M. S. (2015). Moringa oleifera Leaf Extract Ameliorates Glucose, Insulin and Pancreatic Beta Cells Disorder in Alloxan-Induced Diabetic Rats. *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, 6(3), 652.
- Friedewald, W., Levy, R., & Fredrickson, D. (1972). Estimation of LDL-C in Plasma without the use of the Preparative Ultracentrifuge. *Clinical Chemistry*, 18(6), 499-502.
- Galland, F., Duvillard, L., Petit, J., Lagrost, L., Vaillant, G., Brum, J., et al. (2006, July 12th). Effect of insulin treatment on plasma oxidized LDL/LDL Cholesterol ration intypes 2 diabetics patient. *Diabetes Metabolism*, 32, 625-631.

- 239 Hajera, K., Ajijur, R., Mohitosh, B., & Anwar, U. (2011). Water-soluble Fraction of
240 Abelmoschus esculentus L. Interacts with Glucose and Metformin Hydrochloride and
241 Alters their Absorption Kinetics after Coadministration in Rats. *ISRN Pharmaceutics*,
242 6, 260537.
- 243 Kandur, S.V., Goyal, R.K., (2005). Beneficial Effects of Zingiber Officinale Roscoe on
244 FructoseInduced Hyperlipidemia & Hyperinsulinemia in Rats. *Indian J. Exp. Biol.* **43**:
245 1161- 64.
246
- 247 Lenzen, S. (2008). Review: The mechanisms of alloxan- and streptozotocin-induced diabetes.
248 *Diabetologia*, 51, 216–226.
- 249 Luangpiom, A., Kourjampa, W., & Junaimaung, T. (2013). Anti-hyperglycemic Properties
250 ofMoringa oleifera Lam. Aqueous Leaf Extract in Normal and Mildly Diabetic Mice.
251 *British J. Pharmacol. Toxicology* 4(3), 106-109.
- 252 Luka, C., Tijjani, H., Joel, E., Ezejiofor, U., & Onwukike, P. (2013). Hypoglycaemic
253 Properties of Aqueous Extracts of Anacardium occidentale, Moringa oleifera,
254 Vernonia amygdalina and Helianthus annuus: A Comparative Study on Some
255 Biochemical Parameters in Diabetic Rats . *International Journal of Pharmaceutical*
256 *Science Invention*, Volume 2 Issue 7, 16-22.
- 257 Mayfeild, J. (1998). Diagnosis and classification of diabetes; New criteria. *Family of*
258 *physiology* 58 (6), 1355-1362.
- 259 Noor, A., Gunasekaran, S., Manickam, A., & Vijayalakshmi, M. A. (2008). Antidiabetic
260 activity of Aloe vera and histology of organs in streptozotocin –induced diabetic rats.
261 *Curr. Sci.* 94:, 1070– 1076. .
- 262 Ogonnia, S. O., Anyika, E. N., Mbaka, G. O., Utah, P., Ugwu, D., Nwakakwa, N., et al.
263 (2012). Antihyperglycaemic and antihyperlipidaemic effects of aqueous ethanol
264 extract of Tapinanthus globiferus leaves and Treculia africana root bark and their
265 mixture on alloxan diabetic rats. *Agriculture And Biology Journal Of North America*,
266 3(6), 237-246.
- 267 Ogonnia, S. O., Enwuru, N. V., Onyemenem, E. U., & Oyedele, G. A. (2008).
268 Phytochemical evaluation and antibacterial profile of Treculia africana Decne bark
269 extract on gastrointestinal bacterial pathogens. *African Journal of Biotechnology*,
270 7(10), 1385-1389.
- 271 Ogonnia, S., Odimegwu, J., & Enwuru, V. (2008). Evaluation of Hypoglycemic and
272 Hypolipidemic Effects of Aqueous Ethanolic Extract of Treculia africana Decne and
273 Bryophyllum Pinnatum Lam and Their Mixture on Streptozotocin(STZ)-induced
274 Diabetic Rats. *Afr. J. Biotechnol.*, 15(7), 2535-2539.

- 275 Ohno, T., Horio, F., Tanaka, S., Terada, M., & Namikawa, T. a. (2000). Fatty liver and
276 hyperlipidemia in IDDM (insulin dependent diabetes mellitus) of Streptozotocin
277 treated shrews. *Journal of Life Science*, 125-131.
- 278 Oimage, K., Onoagbe, O. I., Georgina, E., Esosa, S. U., Ajeigbe, O. K., & Amegor, O. F.
279 (2011). Effects of aqueous root extract of *Treculia africana* on blood glucose, lipid
280 profile and body weight changes of streptozotocin-induced diabetic and normal rats.
281 *International Journal of Plant Physiology and Biochemistry*, 3(10), 169-175.
- 282 Ortiz-Andrade, R., Rodriguez-lopez, V., & Estrack-Soto, S. (2005). Antidiabetic Effects on
283 Alloxanized and Normoglycemic rat and Some Pharmaceutical Evaluation of
284 *Toungnetorniam Hartmegical*. . *Journal of Ethnopharmacology*: 100(1-3), 74-42.
- 285 Osabor, V., Ogar, D. A., Okafor, P. C., & Egbung, G. (2009). Profile of African bread fruit
286 (*Treculia africana*). *Pakistan Journal of Nutrition*, 8(7), 1005-1108.
- 287 Oyelola, O. O., Moody, J. O., Odeniyi, M. A., & Fakeye, T. O. (2007). Hypoglycemic Effect
288 Of *Treculia Africana* Decne Root Bark In Normal and Alloxan-Induced Diabetic Rats.
289 *Afr. J. Traditional, Complementary and Alternative Medicines*, 387 - 391.
- 290 Rafiu, A., & Luka, C. (2015). Anti-diabetic activity of aqueous seed extract of (*Moringa*
291 *oleifera*) in normal and alloxan Induced Diabetic Rat. *Journal of Biological Sciences*
292 *and Bioconservation*, Volume 7, NUMBER 1, 24-37.
- 293 Richert, K., Martinez., R. R., & Martinez, T. T. (1999). Pharmacist knowledge of common
294 herbal preparations. *Proc. West. Pharmacol. Soc.* 42:, 42, 1-2.
- 295 Ruffo, C., Birnie, A., & Tengas, B. (2001). *Edible Wild Plants of Tanzania*. Nairobi:
296 Regional Land Management.
- 297 Saidu, Y., Nwachukwu, F., Bilbis, L., Faruk, U., & Abbas, A. (2010). Hypoglycaemic and
298 Hypolipidemic Effects of Root Extracts of *Albizzia chevalieri* in Alloxan-induced
299 Diabetic Rats. *Nigerian Journal of Basic and Applied Science*, 18(1), 72-78.
- 300 Sheikhla, A. (2013). *Trigonella foenum-graecum* L. (Fenugreek) as a Medicinal Herb in
301 Animals Growth and Health. *Science International Volume 1 Issue 6*,, 1994-1998.
- 302 Swami, S., Sztalryd, C., & Kraemer, F. B. (1996). Effects of streptozotocin-induced diabetes
303 on low density lipoprotein receptor expression in rat adipose tissue. *Journal of Lipid*
304 *Research*, 37, 229-239.
- 305 Tietz, N. (1990). *Serum Triglyceride Determination*. In: *Clinical Guide to Laboratory Tests*
306 (Second Edition ed.). Philadelphia, Philadelphia, USA: W.B., Saunders Co.
- 307 Trinder, P. (1969). Determination of Blood Glucose in Blood Using Glucose Oxidase with an
308 Alternative Oxygen Acceptor. *Annals of Clin. Biochem*, 6, 24-25.

- 309 Vos, T., Flaxman, A., Naghavi, M., Lozano, R., Michaud, C., Ezzati, M., et al. (2012). Years
 310 lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–
 311 2010: a systematic analysis for the Global Burden of Disease Study. *Lancet* 380
 312 (9859), 2163–96.
- 313 Young, N. L., Saudek, C. D., & Crawford, S. A. (1982). Total hydroxymethylglutaryl CoA
 314 reductase activity in the small intestine and liver of insulin-deficient rats. *Journal of*
 315 *Lipid Research*, 23, 266-275.
- 316 Zafar, M., Naqvi, *. N.-u.-H., & Kaimkhani, M. A. (2009). Altered Liver Morphology and
 317 Enzymes in Streptozotocin Induced Diabetic Rats. *International Journal of*
 318 *Morphology* 27(3), 719-725.