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BIOCHEMICAL EVALUATION OF HARUNGANA MADAGASCARIENSIS LAM AQUEOUS LEAF EXTRACT IN DIABETIC RATS

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ABSTRACT: *Effects of aqueous leaf extract of Harungana madagascariensis Lam. ex Poir (Family: Hypericacea) on alloxan-induced diabetic rats were investigated. 500 mg/kg body weight extract was administered orally twice daily for 7 days. Blood glucose, cholesterol, bilirubin, alanine aminotransferase (ALT) and alkaline phosphatase (AP) levels hitherto raised in diabetic rats consequent upon induction of diabetes, were significantly ($p<0.05$) reduced following administration of the extract, except for ALT ($p>0.05$) . In contrast, the significant ($p<0.05$) decrease in plasma protein of the rats injected with alloxan were significantly ($p<0.05$) increased by administration of the extract compared to diabetic control rats, suggesting membrane structure and integrity of liver cells were restored. Neither alloxan nor the extract had any significant effect on albumin concentration. The results indicate the aqueous extract of Harungana madagascariensis leaf is antihyperglycaemic and antihypercholesterolaemic justifying its folkloric use as a diabetic agent and appears to have the propensity to restore damaged liver cells back to functionality.*

KEYWORDS: Albino Rats, Biochemical Effects, Diabetes Mellitus, Harungana Madagascariensis Lam, Medicinal Plant.

INTRODUCTION

Diabetes mellitus is a syndrome characterized by chronic hyperglycaemia and disturbances of carbohydrate, fat and protein metabolism associated with absolute or relative deficiencies in insulin secretion and/or insulin action (Bennett, 1994). Since antiquity, diabetes has been treated with plant remedies. The art of native medicine has been practiced in Nigeria for many years and the use of certain plants, rituals and incantations would normally be passed on orally to a younger relative. However, a major problem is that they seek to keep the knowledge secret and confidential, so valuable information can be lost whenever a traditional medical practitioner dies before revealing his knowledge to another. Obviously, this method of passing on knowledge of herbs requires the recipient to have a good memory. Thus, there is danger of distortion as well as loss of information. With the aim of documenting some of these effective practices, this study was designed to investigate the hypoglycaemic claims of the aqueous extract of *Harungana madagascariensis* leaf by studying indices of diabetes mellitus such as glycaemic control, lipid profile, as well as albumin, protein and liver marker enzymes using albino rats

LITERATURE / THEORETICAL UNDERPINNING

Diabetes mellitus the most common endocrine disease, affects most populations of the world and thus the need arises to search for cheaper and better modalities of treatment or prevention. Diabetes is characterized by an abnormally high level of glucose in the blood. In type 1 diabetes

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(representing 10% or fewer of all cases), elevated blood glucose results from inadequate secretion of insulin by the islets of Langerhans in the pancreas. Type II diabetes (at least 90% of all cases) results from an insensitivity to insulin. Type II diabetics produce normal or even elevated levels of insulin, but owing to a shortage of insulin receptors, their cells are not responsive to insulin. In both cases, transport of glucose into muscle, liver, and adipose tissue is significantly reduced, and, despite abundant glucose in the blood, the cells are metabolically starved. They respond by turning to increased gluconeogenesis and catabolism of fat and protein. In type I diabetes increased gluconeogenesis consumes most of the available oxaloacetate, but breakdown of fat, and to a lesser extent, protein produces large amounts of acetyl-CoA. This increased acetyl-CoA would normally be directed to the TCA cycle, but with oxaloacetate in short supply, it is used instead for production of unusually large amounts of ketone bodies. Acetone can often be detected on the breath of type I diabetics, an indication of high plasma levels of ketone bodies (Garrett and Crishan, 1999). For both types of diabetes Type 1 and II, control of blood glucose levels, lipid levels, blood pressure and weight will reduce the risk of vascular damage with associated coronary artery disease, cerebrovascular disease, kidney disease, retinal damage and neuroischemic gangrene (Williams, 1994).

The use of complementary and alternative medicine modalities by the public is on the increase worldwide. The therapeutic use of plant medicines for the treatment of diabetes mellitus has drawn the attention of various scientific investigators. The World Health Organisation has recommended further research into the efficacy of medicinal plants especially since many of these plants have proven useful in the treatment of diabetes in areas where insulin is not readily available (WHO, 1980).

Harungana madagascariensis (Family: Hypericacea) is commonly known as Red Blood Tree. It is a shrub or tree that has broad ovate leaves and produces an exudate of a bright orange juice. The plant grows reaching a height of 6 m. The flowers which are white or greyish are densely crowded at the ends of the inflorescence and the fruits are spherical about 2 mm across, yellow at first finally brown, with the remains of the calyx at the base and crowned by the persistent styles (Csurhes and Edwards, 1998). The stem, root and leaf extracts have been used in the treatment of various diseases including dysentery, bleeding piles, trypanosomiasis, fever, cough, black tongue, scabies, jaundice, boils (Sofowora,1993).

METHODOLOGY

Chemicals

Alloxan monohydrate was purchased from Sigma Chemical Company, St. Louis, MO, USA. Assay kits from Randox Ltd, UK were used in estimating glucose, total protein, cholesterol, albumin, urea, alanine aminotransferase, alkaline phosphatase and bilirubin.

Animals

Twenty-five (25) albino rats of the Sprague – Dawley strain weighing between 100g and 230g were purchased from the Nigerian Institute for Medical Research, Yaba, Lagos. They were housed in clean metal cages at a temperature of $25 \pm 2\ ^0$C with 12 hours light/dark cycles. They were acclimatized for one week and fed on grower's pellets (Bendel Feed Mill, Ewu, Edo State, Nigeria) and given water *ad libitum*. Animals were handled in accordance with internationally

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accepted principles for laboratory animal use and care (NIH Publication 85 – 93, revised, 1985).

Induction of Diabetes mellitus

Diabetes mellitus was induced on two consecutive days by the intraperitoneal injection of freshly prepared 100 mg/kg body weight of alloxan monohydrate (Sigma Chemical Company, St. Louis, MO, USA) dissolved in distilled water. 24 hours after the second alloxan injection, fasting blood (16 h) was drained from the tail veins of conscious rats and analyzed. Only rats with fasting blood glucose above 120 mg/dl were used for the diabetic study.

Pharmacological Evaluation

25 rats were randomly divided into 3 groups with Groups 1 and 2 having ten (10) rats each and Group 3 five (5). 500 mg/kg body weight of the aqueous leaf extract of *Harungana madagascariensis* was administered to Group 2 rats orally by gavage twice daily.

Group 1: Diabetic rats received distilled water (Diabetic control)

Group 2: Diabetic rats received *H. madagascariensis* aqueous leaf extract (Diabetic treated)

Group 3: Normal rats received distilled water (Normal control)

Plant Materials

Leaves were collected from *Harungana madagascariensis* growing behind the Pro-Chancellor's Lodge at the University of Benin, Benin City, Nigeria and identified at the Plant Biology and Biotechnology Department Herbarium of the same university. They were subsequently sun-dried and oven-dried (Gallenkamp, UK) at 40 ^{0}C till a constant weight was achieved. The dried leaves were milled (Thomas-Wiley Machine, England) and the sieved powdered sample kept in stopperred glass bottles till needed.

Preparation of Extract

200g of the powdered leaf of *H. madagascariensis* were extracted with 1.5 litres of distilled water in a soxhlet extraction apparatus for 8 hours. The liquid extract was concentrated using a rotary evaporator (Gallenkamp, UK) and the semi-solid dried extract was further dried to a constant weight over a steam bath (Gallenkamp, UK) at 60 ºC, giving a 7.0% yield. 5g of the extract was made up to 100ml and used as stock crude drug.

Blood Collection

Feed was withdrawn from all rats prior to blood collections but free access to water was allowed. Fasting blood was drained from the veins of conscious rats into fluoride citrate treated bottles for glucose analysis and into lithium oxalate specimen bottles for plasma used for other analysis. Blood samples were collected prior to induction of diabetes (baseline), 24 hours after second alloxan injection and then on alternate days thereafter during administration of extract.

Blood samples were centrifuged at 3,500 r.p.m (MSE Minor Bench Centrifuge, London) for 10 min and serum/plasma analyzed using assay kits from Randox Laboratory Ltd, UK.

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Biochemical Analysis

Serum glucose concentration was estimated using enzymatic colorimetric kits (Randox Laboratory Ltd., UK) in which the glucose oxidase / peroxidase / 4-aminophenazone method of Tietz (1990) was adopted. Absorbance was read at 500 nm (Pye Unicam SP 1800 Ultraviolet Spectrophotometer). Plasma cholesterol concentration was estimated as described in the Randox kit where the indicator quinoneimine is formed from hydrogen peroxide and 4-amino antipyrene in the presence of phenol and peroxidase. Absorbance was read at 500 nm. Albumin concentration in the plasma was determined using the method described by Tietz (1987) which is based on the fact that albumin binds quantitatively to the indicator bromocresol green. The albumin BCG complex absorbs maximally at 578 nm. Bilirubin was determined by the reaction with diazolized sulfanilic acid and absorbances read at 578 nm. Plasma total protein was determined using the biuret method for detecting the presence of peptide bonds (Tietz, 1995). Briefly, 0.02 ml of plasma, standard protein solution and reagent blank were pipetted into 3 different test tubes and 1.0 ml biuret reagent solution added. The mixture was incubated for 30 min at 25 ^{0}C and absorbance of the plasma and standard measured against the reagent blank at 546 nm.

Assessment of Liver Enzymes

The activities of plasma alanine aminotransferase (ALT) and alkaline phosphatase (AP) were assayed using colorimetric assay kits (Randox Laboratory Ltd, UK) according to manufacturer's instructions and values expressed in IU/L.

Statistical Analysis

Results are presented as means ± SD of triplicate determinations. The differences between the means of test and control groups were analyzed by student t-test. Statistical significance was set at a value of $p \leq 0.05$.

4.0 Results / Findings

Results obtained are displayed in Tables 1 to 7. Table 1 shows the blood glucose levels of rats before alloxan injection, (Day 0, baseline values) and after, (Days 3, 5, 7 and 9).

Administration of *H. madagascariensis* caused a lowering of serum glucose in the diabetic treated rats (Group 2) compared to control and baseline values ($p<0.05$). After one week administration of the extract, there was a 92.97% decrease in serum glucose concentration compared with control rats (Group 1).

Table 1: Effect of *Harungana madagascariensis* aqueous leaf extract on serum glucose concentration (mg/dl) in alloxan-induced diabetic rats. Treatment began on Day 3

Day	Diabetic Control Rats (Group 1)	Diabetic Treated Rats (Group 2)	Normal Control Rats (Group 3)	Significance
Pre-alloxan 0	74.64 ± 13.00^a (7)	79.60 ± 13.50^b (9)	74.14 ± 14.20^c (5)	^{ab} $p>0.05$ ^{ac} $p>0.05$
Post-alloxan				

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3	127.24 ± 42.00[d] (7)	121.80 ± 5.90[e] (9)	--	[ad] p<0.05 [be] p<0.05
5	137.26 ± 33.60[f] (7)	92.40 ± 26.80[g] (9)	69.90 ± 4.40[h] (5)	[fg] p<0.05 [fh] p<0.05
7	121.26 ± 29.90[i] (7)	67.00 ± 20.00[j] (9)	65.00 ± 13.40[k] (5)	[ij] p<0.05 [ik] p<0.05
9	96.87 ± 24.80[l] (7)	50.20 ± 6.30[m] (9)	67.74 ± 7.00[n] (5)	[lm] p<0.05 [ln] p<0.05

(n) = number of rats. Values are means ± SD of triple determinations.

Total protein levels were significantly (p<0.05) decreased on induction of diabetes (Table 2)

One week oral administration of *H. madagascariensis* extract caused a statistically significant (p < 0.05) reversal.

Table 2: Effect of *Harungana madagascariensis* aqueous leaf extract on total protein concentration (mg/dl) in alloxan-induced diabetic rats. Treatment began on Day 3

Day	Diabetic Control Rats (Group 1)	Diabetic Treated Rats (Group 2)	Normal Control Rats (Group 3)	Significance
Pre-alloxan 0	7.70 ± 1.03[a] (7)	11.16 ± 1.68[b] (9)	11.40 ± 3.91[c] (5)	[ab] p<0.05 [ac] p<0.05
Post-alloxan 3	6.54 ± 1.69[d] (7)	6.13 ± 1.08[e] (9)	--	[ad] p>0.05 [be] p<0.05
5	5.74 ± 1.00[f] (7)	7.36 ± 0.68[g] (9)	8.76 ± 1.91[h] (5)	[fg] p>0.05 [fh] p<0.05
7	5.10 ± 1.30[i] (7)	7.78 ± 1.19[j] (9)	8.60 ± 1.66[k] (5)	[ij] p<0.05 [ik] p<0.05
9	4.10 ± 1.45[l] (7)	9.14 ± 0.93[m] (9)	8.90 ± 1.73[n] (5)	[lm] p<0.05 [ln] p<0.05

(n) = number of rats. Values are means ± SD of triple determinations

Table 3 presents the concentrations of plasma cholesterol in rats before and after treatments. Alloxan injection caused a significant increase in plasma cholesterol levels in the diabetic rats (Groups 1 and 2) when compared to the normal untreated rats (Group 3). Administration of the extract did not cause an immediate reduction but rather further increases up to four days before a significant (p<0.05) reduction by Day 9 ensured.

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Table 3: Effect of *Harungana madagascriensis* aqueous leaf extract on plasma cholesterol levels (mg/dl) in alloxan-induced diabetic rats. Treatment began on Day 3

Day	Diabetic Control Rats (Group 1)	Diabetic Treated Rats (Group 2)	Normal Control Rats (Group 3)	Significance
Pre-alloxan 0	69.47 ± 13.52[a] (7)	93.29 ± 17.16[b] (9)	74.16 ± 18.76[c] (5)	[ab] p<0.05 [ac] p>0.05
Post-alloxan 3	101.90 ± 22.30[d] (7)	121.80 ± 3.00[e] (9)	--	[ad] p<0.05 [be] p<0.05
5	121.76 ± 22.30[f] (7)	130.50 ± 7.46[g] (9)	67.20 ± 14.90[h] (5)	[fg] p>0.05 [fh] p<0.05
7	117.20 ± 19.90[i] (7)	128.60 ± 0.80[j] (9)	74.78 ± 8.40[k] (5)	[ij] p>>0.05 [ik] p<0.05
9	116.09 ± 17.70[l] (7)	85.00 ± 1.81[m] (9)	65.60 ± 7.30[n] (5)	[lm] p<0.05 [ln] p<0.05

(n) = number of rats. Values are means ± SD of triple determinations

Induction of diabetes mellitus did not elicit any significant changes (p>0.05) on plasma albumin levels (Table 4). Administration of the extract did not show any significant changes either (p>0.05) compared to pre-treatment values.

Table 4: Effect of *Harungana madagascariensis* aqueous leaf extract on plasma albumin concentration (mg/dl) in alloxan-induced diabetic rats. Treatment began on Day 3

Day	Diabetic Control Rats (Group 1)	Diabetic Treated Rats (Group 2)	Normal Control Rats (Group 3)	Significance
Pre-alloxan 0	4.50 ± 0.97[a] (7)	3.72 ± 0.21[b] (9)	5.70 ± 1.25[c] (5)	[ab] p>0.05 [ac] p>0.05
Post-alloxan 3	4.30 ± 0.90[d] (7)	3.80 ± 0.21[e] (9)	--	[ad] p>0.05 [be] p>0.05
5	3.50 ± 0.59[f] (7)	4.30 ± 0.48[g] (9)	5.20 ± 1.10[h] (5)	[fg] p>0.05 [fh] p>0.05
7	3.34 ± 0.22[i] (7)	4.81 ± 0.08[j] (9)	5.22 ± 1.10[k] (5)	[ij] p>0.05 [ik] p>0.05
9	3.50 ± 0.33[l] (7)	3.80 ± 0.22[m] (9)	5.30 ± 1.10[n] (5)	[lm] p>0.05 [ln] p>0.05

(n) = number of rats. Values are means ± SD of triple determinations.

Plasma bilirubin levels were significantly (p<0.05) raised by alloxan induction (Table 5). Administration of diabetic rats (Group 2) with the extract caused a 73.91% reduction after one week.

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Table 5: Effect of *Harungana madagascariensis* aqueous leaf extract on plasma total bilirubin in alloxan-induced diabetic rats. Treatment began on Day 3

Day	Diabetic Control Rats (Group 1)	Diabetic Treated Rats (Group 2)	Normal Control Rats (Group 3)	Significance
Pre-alloxan 0	1.06 ± 0.23^{a} (7)	1.06 ± 0.86^{b} (9)	1.34 ± 0.18^{c} (5)	^{ab} p>0.05 ^{ac} p>0.05
Post-alloxan 3	2.73 ± 2.28^{d} (7)	3.40 ± 2.62^{e} (9)	--	^{ad} p<0.05 ^{be} p<0.05
5	2.04 ± 1.02^{f} (7)	2.90 ± 1.90^{g} (9)	1.10 ± 0.16^{h} (5)	^{fg} p>0.05 ^{fh} p>0.05
7	1.65 ± 0.48^{i} (7)	0.71 ± 0.84^{j} (9)	1.26 ± 0.30^{k} (5)	^{ij} p<0.05 ^{ik} p>0.05
9	1.46 ± 0.72^{l} (7)	0.43 ± 0.32^{m} (9)	1.16 ± 0.11^{n} (5)	^{lm} p<0.05 ^{ln} p>0.05

(n) = number of rats. Values are means ± SD of triple determinations

The results for the effect of the extract on some marker enzymes in liver disease are presented in Tables 6 and 7. Alloxan induction caused significant increases ($p<0.05$) in ALT activities in Group 2 rats. Though administration of the extract had a reductive effect, it was not statistically significant ($p>0.05$) after one week of therapy (Table 6). Alloxan induction also significantly increased ($p<0.05$) alkaline phosphatase (AP) activities in diabetic rats. Administration of the extract elicited a reduction from 65.50 ± 10.10 IU/L on day 3 to 12.30 ± 3.54 IU/L by day 9, ($p<0.05$) (Table 7).

Table 6: Effect of Harungana madagascariensis aqueous leaf extract on Alanine aminotransferase activity (IU/L) in alloxan-induced diabetic rats. Treatment began on Day 3

Day	Diabetic Control Rats (Group 1)	Diabetic Treated Rats (Group 2)	Normal Control Rats (Group 3)	Significance
Pre-alloxan 0	23.26 ± 11.20^{a} (7)	23.89 ± 2.52^{b} (9)	25.30 ± 5.80^{c} (5)	^{ab} p>0.05 ^{ac} p>0.05
Post-alloxan 3	23.4 ± 14.80^{d} (7)	31.86 ± 1.71^{e} (9)	--	^{ad} p>0.05 ^{be} p<0.05
5	18.84 ± 8.57^{f} (7)	29.41 ± 4.25^{g} (9)	17.34 ± 6.36^{h} (5)	^{fg} p<0.05 ^{fh} p>0.05
7	17.24 ± 6.23^{i} (7)	28.64 ± 3.84^{j} (9)	18.90 ± 6.47^{k} (5)	^{ij} p<0.05 ^{ik} p>0.05
9	16.76 ± 7.73^{l} (7)	26.63 ± 4.14^{m} (9)	20.06 ± 3.09^{n} (5)	^{lm} p<0.05 ^{ln} p>0.05

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(n) = number of rats. Values are means ± SD of triple determinations.

Table 7: Effect of *Harungana madagascariensis* aqueous leaf extract on plasma alkaline phosphate activity (IU/L) in alloxan-induced diabetic rats. Treatment began on Day 3

Day	Diabetic Control Rats (Group 1)	Diabetic Treated Rats (Group 2)	Normal Control Rats (Group 3)	Significance
Pre-alloxan 0	40.89 ± 9.33^{a} (7)	57.74 ± 14.75^{b} (9)	36.98 ± 14.17^{c} (5)	^{ab} $p<0.05$ ^{ac} $p>0.05$
Post-alloxan 3	52.21 ± 8.74^{d} (7)	65.51 ± 10.07^{e} (9)	--	^{ad} $p<0.05$ ^{be} $p>0.05$
5	46.74 ± 7.34^{f} (7)	41.49 ± 12.44^{g} (9)	34.88 ± 12.08^{h} (5)	^{fg} $p>0.05$ ^{fh} $p>0.05$
7	39.50 ± 6.55^{i} (7)	15.87 ± 2.33^{j} (9)	36.16 ± 11.08^{k} (5)	^{ij} $p<0.05$ ^{ik} $p>0.05$
9	34.04 ± 4.60^{l} (7)	12.29 ± 3.48^{m} (9)	36.72 ± 11.91^{n} (5)	^{lm} $p<0.05$ ^{ln} $p>0.05$

(n) = number of rats. Values are means ± SD of triple determinations

DISCUSSION

The results obtained show that serum glucose levels increased significantly ($p<0.05$) when compared with basal and control values, thus confirming that animals used in this study were made diabetic by the alloxan injected. Diabetes mellitus may be defined as a state of chronic hyperglycaemia usually accompanied by glycosuria (Whitby *et al.*, 1984). The decrease in serum glucose levels following treatment with the extract essentially indicated the effectiveness of *H. madagascariensis* as an antihyperglycaemic agent. This is in consonance with other researchers who have also reported antihyperglycaemic activities of some plants (Nimenibo-Uadia and Osagie, 2001; Atawodi and Muazu, 2003; Afolayan and Sunmonu, 2010).

Decreases observed in protein concentration may be due to the fact that in a diabetic situation, energy metabolism is shifted from carbohydrate to other alternative sources such as protein and fat. Also, damage to the liver by alloxan induction of diabetes may have impaired protein synthesis by the liver. Reduced plasma total protein may occur due to impaired protein synthesis (as in cases of malnutrition), liver disease among others (Whitby *et al.*, 1984). However administration of the extract of *H. madagascariensis* caused a significant ($p<0.05$) increase in protein concentration after 5 days of treatment (Day 7) suggesting the plant may have restored some functionality to the liver architecture.

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Cholesterol as well as other lipids such as triacylglycerols are usually elevated in diabetes mellitus. Since cholesterol concentration in the diabetic rats took a while before significant reductions by the extract were observed, it suggests *H. madagascariensis* does have an antihypercholesterolaemic effect, which probably acts after repeated doses or at a higher concentration. Other workers have reported antihypercholesterolaemic / antihyperlipidaemic effects of some medicinal plants (Nimenibo-Uadia and Osagie, 2001; Atawodi and Muazu, 2003; Afolayan and Sunmonu, 2010; Tripathi and Verma, 2014; Janapti, 2015).

Albumin is quantitatively the most important of the plasma proteins, and its half-life in plasma is 20 days, thus out-lasting the duration of diabetic experimentation in this study. Hence, neither alloxan induction nor treatment of the diabetic rats with the extract elicited significant differences in albumin levels.

Hyperbilirubinaemia as seen in the diabetic animals is one of the conditions indicative of liver damage. The 73.91% reduction in hyperbilirubinaemia observed on therapy suggests, H. madagascariensis aqueous leaf extract has the propensity to repair damaged liver structure.

Alanine aminotransferase (ALT) or Aspartate aminotransferase (AST) activity determinations are routine tests for hepatocellular integrity but plasma ALT (which we studied) is more liver-specific (Whitby *et al.*, 1984). Alkaline phosphatase (AP) activity estimation is a routine test for presence of cholestasis in liver damage/disease. Its elevation following alloxan induction of rats in the present study, thus indicates liver damage. Cholestasis is most commonly due to extrahepatic obstruction of the bile ducts (Whitby *et al.*, 1984). Administration of the extract did cause an 81.22% decrease in AP activity in the diabetic rats following one week of therapy, thus confirming the healing effects of *H. madagascariensis* aqueous leaf extract on the liver.

Implication of Research

This research documents and scientifically justifies the ethnomedicinal use of *Harungana madagascariensis* as an atidiabetic agent. It is thus a good candidate for further research efforts. Traditional medicine is relevant in the health services of the low socio-economic class due to the fact that it is readily available and at a cost they can afford. In addition, new drugs are often beyond the reach of the poor, where up to 80% of the population use medicinal plants as remedy against infections and diseases (Omage *et al.*, 2016). It is therefore pertinent to investigate these plants in the laboratory for safety assessments and scientific justification or otherwise of claims of efficacy. These are the first of such studies on *H. madagascariensis* to the best of our knowledge.

CONCLUSION

In conclusion, the aqueous leaf extract of *Harungana madagascariensis* reduced blood glucose, cholesterol, bilirubin, alanine aminotransferase, alkaline phosphatase levels hitherto raised by alloxan-induced diabetes, and increased total protein concentrations that were decreased by alloxan injection of albino rats. Most antidiabetic plants have been reported to contain saponins, alkaloids, flavonoids, tannins, glycosides that are usually implicated as possessing antidiabetic properties (Harborne *et al.*, 1974: Oliver-Bever, 1980; Nimenibo-Uadia *et al*., 2017). Thus, the antidiabetic effects of *Harungana madagascariensis* may be due to any of these bioactive metabolites.

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Future Research

It should not always be assumed that all plants are safe simply because they are found growing in natural habitats. Thus the toxicological evaluation of this plant is in focus.

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