Journal of Pharmaceutical and Biological Sciences 2022;10(1):29–36

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Journal of Pharmaceutical and Biological Sciences

Journal homepage: https://www.jpbs.in/

Original Research Article

MPharmacological potential of *Lactura taraxacifolia* leaf on blood glucose levels, lipid profile, and oxidative stress parameters in diabetic rats

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ARTICLE INFO

Article history:
Received 21-01-2022
Accepted 10-05-2022
Available online 06-07-2022

Keywords:
Lactuca taraxacifolia
lipid profile
Antioxidant Potential
Diabetes
Streptozotocin

ABSTRACT

Lactuca taraxacifolia is a plant from tropical regions traditionally used in Africa as an anti-diabetic. The aim of the work was to evaluate the antidiabetic and antioxidant potential of the aqueous extract of *L. taraxacifolia* leaves (AELT) in diabetic rats. To induce diabetes, streptozotocin (55 mg/kg) was injected intraperitoneally into rats. Diabetic animals were divided into groups and treated with vehicle, glibenclamide (10 mg/kg) and AETL (150, 300 and 450 mg/kg). Body weight, blood glucose level, water and food consumption, lipid and oxidative stress parameters were assessed. AELT (450 mg/kg) significantly ($p < 0.05$ to $p < 0.001$) prevented weight loss, polyphagia, and polydipsia in diabetic rats. Hyperglycemia, total cholesterol, triglycerides, low-density lipoprotein cholesterol, and malondialdehyde were significantly reduced ($p < 0.05$ to $p < 0.001$) in diabetic rats treated with AETL. The levels of reduced glutathione, high-density lipoprotein cholesterol, catalase, and superoxide dismutase activities were also increased ($p < 0.05$ to $p < 0.001$) with AELT. AELT can improve postprandial hyperglycemia, treat diabetes mellitus, and protect pancreas against damage induced by oxidative stress. The results obtained from this study justify the ethnobotanical use of AELT as a treatment of diabetes mellitus.

1. Introduction

Diabetes mellitus is a non-communicable disease that represents a major public health problem around the world. There are two main types of diabetes mellitus, type 1 diabetes caused by the body's inability to produce insulin and type 2 diabetes caused by the body's inability to use the insulin it produces effectively. Hyperglycemia is a common effect of uncontrolled diabetes, which over time can cause significant damage, especially to nerves and blood vessels.[1] Worldwide, 463 million people were diabetic in 2019.[2] This number will reach nearly 700 million in 2045. According to estimates by the World Health Organization, by 2030, diabetes could become the seventh leading cause of death in the world.[3]

Diabetes treatment has long relied on changes in diet, injecting insulin and taking oral diabetes medications.[4] Despite the use of these antidiabetics, therapy for diabetes remains a major problem. In addition, the regular administration of insulin and oral hypoglycemic agents leads to undesirable effects.[5] Therefore, a therapeutic supplement composed of plant extracts would be important to optimize the management of diabetes.[6] These plants constitute an inexhaustible resource which provides the majority of the active principles of pharmaceutical products. Scientific work on medicinal plants may lead to the development of phytomedicines as alternative strategies.[7]

Lactuca taraxacifolia (Willd.) Schum (Asteraceae) commonly known as Dandelion is a tropical plant traditionally used in Africa against liver disease, high blood

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https://doi.org/10.18231/j.jpbs.2022.006

pressure, dyslipidemia, cough, and diabetes.[8,9] Previous work has shown that the hydro-ethanolic and ethanolic extracts of *L. taraxacifolia* leaves contain polyphenols, flavonoids, saponins, terpenoids, alkaloids, and tannins.[10,11] The antidiabetic, antioxidant, and lipid-lowering properties of the hydro-ethanolic extract of *L. taraxacifolia* leaf have also been proven.[12–14] Recent work has demonstrated the antidiabetic effect of the ethanolic extract of *L. taraxacifolia* leaves on alloxan-induced diabetic rats.[11] However, no anti-diabetic, lipid-lowering and antioxidant studies have yet been carried out on the aqueous extract of *L. taraxacifolia* leaves. Thus, the aim of this study was to evaluate the hypolipidemic, hypoglycemic, and antioxidant potential of the AELT in diabetic rats.

2. Materials and Methods

2.1. Chemicals

Streptozotocin, and biochemical kits were provided by Sigma Aldrich (St. Louis, USA). D-glucose and chloride soduim were provided by Edu-Lab Biology Kit (Bexwell, Norfolk PE38 9GA, UK). Glibenclamide, ketamine, and diazepam were purchased from a local pharmacy store. Drugs and chemicals were obtained commercially in analytical grade.

2.2. Harvest and identification of plant material

Lactuca taraxacifolia leaves were harvested in Kaélé (Cameroon) in July 2018. A plant sample was identified by the botanist Dr. Todou Gilbert, and kept at the National Herbarium in Yaoundé (Cameroon) under the number 8011/SRF/cam. Then, the harvested leaves were dried away from the sun and crushed until a fine powder was obtained.

2.3. Preparation of the crude extract

The fine powder of *L. taraxacifolia* leaves (200 g) was poured into 3 L of distilled water and the mixture was heated for 45 min. Once cooled, the decoction was filtered using Wattman No. 1 filter paper. The filtrate obtained was evaporated in an oven at 45 °C for 48 h in order to obtain 20.6 g of crude extract with an extraction yield of 10.3%.

2.4. Qualitative phytochemical study

Qualitative phytochemical study was carried out for aqueous extract of *L. taraxacifolia* leaves using standard procedures to demonstrate the presence of glycosides, phenols, anthraquinones, flavonoids, saponins, tannins, steroids, alkaloids, and terpenoids.[15]

3. Animals

The animal material consisted of male albino rats of the Wistar strain, aged 16 to 18 weeks with a weight varying between 200 and 300 g. These animals were provided by the animal facility of the Department of Biological Sciences of the University of Ngaoundéré (Cameroon) and kept in polystyrene cages (n = 5) under conditions of room temperature (25 ± 2 ° C) and natural light (12 hour light-dark cycle). Drinking water and food were given ad libitum. Animals were acclimatized for 14 days under laboratory conditions before the start of each test. This study was approved by the Cameroon National Ethics Committee (Ref. N°. FWIRB 00001954).

3.1. Induction of diabetes and treatment of animals

After 24 h of fasting, Type 1 diabetes mellitus (T1DM) was induced in rats following intraperitoneal injection of streptozotocin (55 mg/kg) in ice cold sodium citrate buffer (0.01 mol/L, pH 4.4). Immediately, the rats were administered a glucose solution (5%) orally to prevent glycemic shock. Seventy-two hours (72 h) after, blood glucose level was assessed and animals with a glycaemia greater than or equal to 200 mg/dL were considered diabetics.[16]

Thirty rats (5 normal rats and 25 diabetic rats) were divided into groups (n = 5) and orally treated for 4 weeks. Groups 1, 2, and 3 received the extract at doses of 150, 300, and 450 mg/kg b.w respectively. Group 4 (standard control) received a glibenclamide (10 mg/kg b.w). Group 5 (diabetic control) received distilled water (10 mL/kg b.w). Group 6 (normal control) received distilled water (10 mL/kg b.w). Body weight Blood glucose level, water and food intake were assessed on days 0, 7, 14, 21, and 28 of treatment.

3.2. Collection of blood and pancreas tissue

Animals fasted for 24 hours at the end of treatment were anesthetized by an intraperitoneal injection of diazepan (10 mg/kg) and ketamine (50 mg/kg) and then dissected immediately. The blood sample was taken into tubes without anticoagulant and centrifuged for 20 min at 3000 rpm (4 °C). The resulting serum was aliquoted and stored at -20 °C for subsequent biochemical assays. After taking blood samples, the pancreas was removed and stored in 10% formalin for histological sections.

3.3. Biochemical assays

Blood glucose level was determined using glucometer (Accu-Chek). Blood insulin level was evaluated using rat enzyme linked immunosorbent assay insulin kit. Triglycerides (TG), total cholesterol (TC), high density lipoprotein cholesterol (HDL-c), low density lipoprotein cholesterol (LDL-c), reduced gluthation (GSH), malondialdéhyde (MDA), and superoxide dismutase (SOD) and catalase (CAT) activity were evaluated using commercial kits.

3.4. Histopathological examination of pancreas

For histopathological analysis, pancreatic tissues of type 1 diabetic rats were fixed in 10% formaldehyde solution for 2 days. After dehydration in the graduated series of alcohol included in paraffin blocks, the pancreas samples were cut (4 μm) using a semi-automatic rotator microtome.

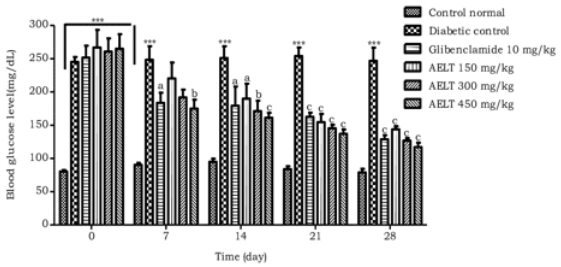

Fig. 1: Each value represents mean ± Standard Error of Mean, n = 5. ***p < 0.001 compared to the normal control. ap < 0.05; bp < 0.01; cp < 0.001 compared to the diabetic control. AELT: aqueous extract of *Lactuca taraxacifolia* leaves\

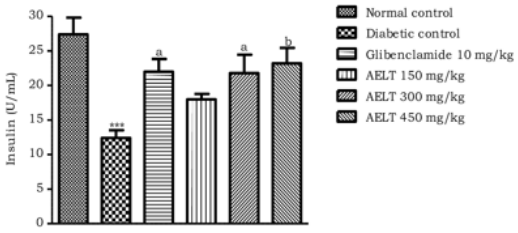

Fig. 2: Each value represents mean ± Standard Error of Mean, n = 5. ***p < 0.001 compared to the normal control. ap < 0.05; bp < 0.01 compared to the diabetic control. AELT: aqueous extract of *Lactuca taraxacifolia* leaves.

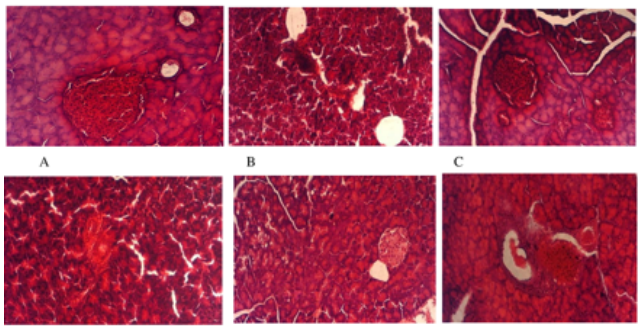

Fig. 3: (A) Normal control group; (B) Diabetic control group; (C) Standard group; (D) AELT 150 mg/kg; (E) AELT 300 mg/kg; (F) AELT 450 mg/kg. AELT: aqueous extract of *Lactuca taxacifolia* leaves.

4. Statistical Analysis

The results were expressed as mean ± SD (Standard derivation). Data were analyzed using one-way ANOVA followed by the Tukey posttest and two-way ANOVA followed by the Bonferroni posttest using Graph Pad Prism version 5.0 software. A value of $p < 0.05$ was considered statistically significant.

5. Results

5.1. Phytochemical screening

Qualitative phytochemistry has shown that AELT contains glycosides, flavonoids, steroids, phenols, alkaloids, tannins, and anthraquinones. However, we note the absence of saponins and terpenoids in AELT (Table 1).

5.2. Body weight, food, and water intake

Throughout the treatment, there was a significant decrease ($p < 0.001$) in the body weight of the untreated diabetic animals, compared to the normal control group (Table 2). In addition, glibenclamide caused a significant increase in body weight on days 14 ($p < 0.01$), 21 ($p < 0.001$) and 28 ($p < 0.001$), compared to the disease control group. Likewise, AETL (450 mg/kg) significantly increased the body weight of rats on days 7 ($p < 0.05$), 14 ($p < 0.05$), 21 ($p < 0.001$), and 28 ($p < 0.001$). On days 21 and 28, a significant increase ($p < 0.01$) in body weight was recorded at the dose of 300 mg/kg of AELT.

Compared to the normal control group, a significant increase in food consumption was noted in the diabetic control group on days 14 ($p < 0.05$), 21 ($p < 0.01$), and 28 ($p < 0.01$) of treatment (Table 2). Compared to the diabetic control group, a significant ($p < 0.05$) decrease in food consumption was observed on days 21 and 28 with glibenclamide ($p < 0.01$) and AELT (450 mg/kg).

A significant increase ($p < 0.01$; $p < 0.001$) in water intake was observed in the diabetic control group on days 21 and 28 of the experiment, compared to the normal control group (Table 2). Furthermore, glibenclamide significantly lowered ($p < 0.01$) water consumption on day 28, compared to the diabetic control group. Likewise, water consumption increased ($p < 0.01$) on days 21 ($p < 0.05$) and 28 in rats receiving AELT at the dose of 450 mg/kg.

5.3. Blood glucose level

Compared to the normal control group, blood glucose levels of all animals significantly increased ($p < 0.001$) on day 0 of experiment. Likewise, we note throughout the treatment, a significant increase ($p < 0.001$) in the glycemia of untreated diabetic animals (Figure 1).

On the other hand, compared to the sick control group, blood glucose level decreased on the 7th day of treatment in rats treated with glibenclamide ($p < 0.05$) and AELT at the

Table 1: Qualitative phytochemical screening of aqueous extracts of *L. taraxacifolia* leaves

Chemical compounds	Aqueous extracts of L. taraxacifolia leaves
Phenols	+
Flavonoids	+
Tannins	+
Anthraquinones	+
Terpenoids	-
Saponins	-
Glycosides	+
Alkaloids	+
Steroids	+

+ : presence ; - : absence

Table 2: Effects of AELT on body weight, food, and water intake in T1DM rats

	Time (day)	Group					
		Normal control	Diabetic control	Glibenclamide 40 mg/kg	AELT 150 mg/kg	AELT 300 mg/kg	AELT 450 mg/kg
Relative body weight (%)	0	100.0±0.0	100±0	100.0±0.0	100.0±0.0	100.0±0.0	100.0±0.0
	7	104.4±0.6	98.1±1.8**	102.6±0.8	100.9±0.5	102.1±0.3	100.8±0.7a
	14	106.2±0.4	98.8±2.1***	105.5±1.2b	102.1±1.0	103.3±0.9	104.1±0.5a
	21	108.8±0.8	98.1±1.9***	106.7±1.3c	102.0±1.3	104.8±1.2b	106.3±0.9c
	28	113.1±.0.4	99.8±2.4***	107.6±1.0c	102.4±1.6	105.1±1.7b	108.3±1.3c
Food intake (g/kg)	0	15.5±0.34	16.8±0.4	14.9±1.0	16.5±0.9	16.9±0.7	17.0±1.0
	7	18.1±0.9	20.6±0.9	17.8±0.3	18.2±1.4	18.9±0.4	16.4±0.6
	14	20.0±0.9	23.8±1.1*	20.8±1.1	22.5±1.4	21.3±0.6	21.6±1.6
	21	21.2±1.2	26.5±1.1**	21.8±0.9a	24.4±1.3	23.2±0.6	23.1±0.6a
	28	22.9±1.0	28.0±1.4**	23.4±0.9b	26.8±0.7	25.5±0.8	23.9±0.8b
Water intake (mL/kg)	0	6.3±0.4	7.7±0.3	6.7±0.5	6.0±0.6	8.5±0.4	7.1±0.7
	7	8.1±0.7	11.3±1.1	10.0±0.4	8.9±.0.6	11.3±0.4	8.9±1.1
	14	11.4±1.1	15.0±1.3	11.2±1.0	12.6±.0.4	14.2±0.5	10.9±1.1a
	21	12.6±1.0	17.5±0.6**	14.1±1.2	15.0±.0.4	15.9±0.8	13.7±0.7
	28	14.3±1.0	21.4±0.8***	16.1±1.6b	18.9±.2.0	18.1±1.4	16.1±0.9b

Each value represents mean ± SEM, n=5. *p < 0.05; **p < 0.01; **p < 0.001 compared to the normal control. ap < 0.05; bp < 0.01; cp < 0.001 compared to the diabetic control. AELT: aqueous extract of *Lactuca taraxacifolia* leaves.

Table 3: Effects of AELT on lipid profil and antioxidant parameters in T1DM rats

Group	Normal control	Diabetic control	Glibenclamide 10 mg/kg	AELT 150 mg/kg	AELT 300 mg/kg	AELT 450 mg/kg
Cholesterol (mg/dL)	95.9±8.8	131.8±5.4*	86.7±8.4b	100.1±6.8a	91.3±4.7b	82.3±4.8c
Triglyceride (mg/dL)	52.9±8.2	90.6±4.5**	47.0±6.2b	68.8±6.7	52.8±5.7b	49.0±5.4b
LDL-c (mg/dL)	46.1±6.9	93.7±6.9***	40.9±5.7c	46.4±2.1c	38.8±2.7c	30.4±2.3c
VLDL-c (mg/mL)	10.5±1.6	18.1±0.9**	9.4±1.2c	13.7±1.3	10.5±1.1b	9.8±1.1b
HDL-c (mg/dL)	39.2±4.7	19.9±1.7*	36.4±2.1a	39.8±2.8b	41.9±3.2b	42.1±5.4b
MDA (mg/dL)	11.5±1.1	20.6±1.6**	16.1±1.9	14.3±1.6	13.0±1.4a	11.1±1.5b
GSH (mg/dL)	33.5±3.0	16.8±2.1*	37.6±3.6b	33.2±2.9a	43.2±3.1c	51.2±4.4c
CAT (U/L)	44.1±4.0	24.6±2.8*	41.4±3.4a	42.6±5.4a	44.4±3.4a	45.6±2.6b
SOD (U/L)	33.7±2.3	15.5±2.4**	30.4±2.9b	31.2±2.4b	31.6±3.0b	32.7±3.1b

Each value represents mean ± SEM, n=5. ***p < 0.001 compared to the normal control. ap < 0.05; bp < 0.01; cp < 0.001 compared to the diabetic control. AELT: aqueous extract of Lactuca taraxacifolia leaves, HDL-c: high-density lipoprotein cholesterol, LDL-c: low-density lipoproteincholesterol, VLDL-c: very low-density lipoprotein cholesterol.

dose of 450 mg/kg ($p < 0,01$) (Figure 1). On day 14, blood glucose level significantly decreased after administration of standard drug ($p < 0.05$) and AELT at doses of 150 ($p < 0.05$), 300 ($p < 0.05$), and 450 mg/kg ($p < 0.001$). This decrease was greater ($p < 0.001$) on days 21 and 28 in all groups of test animals.

5.4. Insulin levels

Compared to the normal control, there is a significant ($p < 0.001$) decrease in blood insulin level in untreated T1DM rats. Compared to T1DM untreated rats, an increase in insulin level was noted in animals receiving glibenclamide ($p < 0.05$) and AETL at doses of 300 ($p < 0.05$) and 450 mg/kg ($p < 0.01$) (Figure 2).

5.5. Biochemical parameters

The effects of AELT on the lipid profile and oxidative stress parameters of T1DM animals are shown in Table 3. In fact, compared to the normal control, a significant increase in the level of TC ($p < 0.05$), TG ($p < 0.01$), LDL-c ($p < 0.001$), VLDL-c ($p < 0.01$), and a significant ($p < 0.001$) decrease in HDL-c level were observed in untreated diabetic animals. However, a significant decrease in TC level was recorded in rats treated with glibenclamide ($p < 0.01$) and AELT at doses of 150 ($p < 0.05$), 300 ($p < 0.01$), and 450 mg/kg ($p < 0.001$), compared to the group of untreated diabetic animals. Likewise, TG level significantly decreased ($p < 0.01$) after administration of glibenclamide and AELT (300 and 450 mg/kg). There was a significant ($p < 0.001$) decrease in LDL-c levels with glibenclamide and all doses of AELT. The VLDL-c level was significantly reduced ($p < 0.001$; $p < 0.01$) in rats receiving glibenclamide and AELT (300 and 450 mg/kg). On the other hand, a significant increase in HDL-c level was recorded in the animals received glibenclamide ($p < 0.05$) and AELT ($p < 0.01$), compared to the disease control group.

A significant increase ($p < 0.01$) in MDA level and a significant decrease in GSH level ($p < 0.05$), and CAT ($p < 0.05$) and SOD ($p < 0.01$) activity was recorded in untreated diabetic rats, compared to the normal control group (Table 3). However, a significant decrease in MDA level was noted with the AELT at doses of 300 ($p < 0.05$) and 450 mg/kg ($p < 0.01$), compared to the diabetic control group. On the other hand, a significant increase ($p < 0.01$) in GSH level was recorded in the animals of the standard control group ($p < 0.01$) and those treated with the AELT at doses of 150 ($p < 0.05$), 300 ($p < 0.001$), and 450 mg/kg ($p < 0.001$). The activity of CAT was significantly increased with glibenclamide ($p < 0.05$) and AELT at doses of 150 ($p < 0.05$), 300 ($p < 0.05$), and 450 mg/kg ($p < 0.01$). In addition, T1DM rats receiving standard drug and all doses of AELT showed a significant ($p < 0.01$) increase in SOD activity.

5.6. Histological sections of pancreas in T1DM rats

Histological sections of the pancreas of animals in the normal control group show islets of Langerhans of normal size (Figure 3 A). However, a reduction in the number and size of islets was observed in the pancreas of untreated diabetic animals group (Figure 3 B). Administration of the AELT and glibenclamide significantly reduced the destruction of pancreatic islets in diabetic rats (Figure 3 C-F).

6. Discussion

Preliminary phytochemical analysis revealed the presence of bioactive compounds such as sterols, phenols, glycosides, flavonoids, tannins, and alkaloids in AELT. The antidiabetic capacity of flavonoids and tannins to regenerate the pancreatic β cell has been proven by previous research.[17] Sterols and glycosides can lower blood glucose levels in diabetic animals.[18] Glycosides have the potential to significantly inhibit α-amylase activity and thus prevent postprandial hyperglycemia.[19] The studies by Sireesha et al.[20] showed that flavonoids slow down the intestinal absorption of glucose. Polyphenols, glycosides, tannins, and flavonoids can protect tissues against oxidative damage.[21] Flavonoids and polyphenols have lipid-lowering activity.[22]

One of the common symptoms of diabetes mellitus is the gradual loss of body weight due to structural protein breakdown and abnormal carbohydrate metabolism.[23,24] In the present work, the drop in body weight of untreated diabetic animals is due to the hydrolysis of lipid and protein stores in tissues for energy production, due to the inability of cells to utilize blood glucose.[25] The increase in body weight observed in diabetic rats given AELT may be the result of their hypoglycemic effect which prevents loss of body weight.[26] It can also be explained by the fact that AELT would have induced a reversal of proteolysis, glycogenolysis and gluconeogenesis.[27]

The increased consumption of water and food regularly observed in diabetic patients is due to an insulin deficiency which is the consequence of the destruction of pancreas tissues.[26]Polyphagia is a crucial symptom of diabetes, which essentially tells us about the reestablishment of insulin secretion as well as the degree of glucose utilization by cell.[28] In this present work, we observed an increase in food consumption in the untreated diabetic rats group and a decrease in food intake in animals receiving AELT (300 and 450 mg/kg). This increase in food consumption indicates that the body cannot use the glucose, which it is nevertheless abundantly provided with, which it draws from its reserves of lipids and proteins for its energy metabolism.[28] In addition, the lack of insulin makes it difficult to signal hunger pangs to the satiety center in the hypothalamus. The decrease in food intake in rats receiving various doses of AELT may be due to the drop in blood

sugar observed in these groups.

The presence of considerable polydipsia in diabetics is inevitably due to the decrease in insulinemia, and the disappearance of this phenomenon is explained by the reestablishment of plasma glucose levels. In this study, the increase in water consumption (polydipsia) in untreated diabetic rats could be caused by hyperglycemia that overflows in the urine leading to dehydration. In the animals groups treated with AELT, a decrease in water consumption was noted; which could indicate the insulinomimetic or insulin-secreting action of AELT.[29]

The two physiopathologies of diabetes mellitus are insulin deficiency and insulin resistance. STZ causes partial destruction of the β cells of the pancreas and therefore an insulin deficiency. In the present work, hyperglycemia and hypoinsulinemia were noted in untreated diabetic rats. However, AELT induced a significant increase in insulinemia and a significant decrease in blood sugar almost in a manner similar to the standard product (glibenclamide). These pharmacological effects may result from an insulinomimetic and insulin-secreting action of AELT, which is further confirmed by the histology of the pancreas of animals treated with AELT and glibenclamide, which showed an increase in the number and the size of the islets of the pancreas.

Diabetes is often associated with a disruption of the lipid profile, which is an abnormal rise in the levels of triglycerides, total cholesterol, phospholipids, and a change in the composition of the lipoprotein.[30] Hypertriglyceridemia and hypercholesterolemia are the main factors involved in the development of coronary heart disease and atherosclerosis which is a complication of diabetes mellitus.[31] Insulin deficiency leads to hyperlipidemia due to the inability to activate lipoprotein lipase. This is because insulin inhibits the activity of 3-hydroxy-3-methyl-glutaryl coenzyme A reductase (HMG-CoA reductase), which will cause dyslipidemia.[32] In this work, the lipid profile of diabetic rats treated with the different doses of AELT improved the low level of TG, TC, VLDL-c, and LDL-c and the high level of HDL-c. Previous studies have reported that extracts of *Baillonella toxisperma* and *Guiera senegalensis* improve the lipid profile of diabetic rats.[33,34] AELT is believed to work by stimulating the secretion of insulin by the remaining pancreatic beta cells, as the insulin decreases the activity of HMG-CoA reductase.[35] The hypotriglyceridemic effect observed is thought to be due to an inhibition of tissue lipolysis.[36] AELT would have inhibited hormone-sensitive lipase, thus promoting the storage of fat in adipocytes and the release of free fatty acids into the bloodstream. AELT improves the lipid profile of diabetics and therefore prevents the formation of arteriosclerosis and reduces cardiovascular risks. This is justified by the significant increase in cardioprotective lipid (HDL-c) observed in this study.

Diabetes mellitus causes increased production of free radicals and/or impaired antioxidant defenses.[37] In the present work, MDA level increased while GSH level and the activity of antioxidant enzymes (CAT and SOD) decreased in T1DM rats. These results may be due to the auto-oxidation of glucose, the formation of free radicals and the nitric oxide.[38] Administration of AELT reduced the level of MDA and increased the level of GSH and activity of antioxidant enzymes in diabetic rats. AELT would have the potential to trap free radicals in order to restore the antioxidant parameters disturbed by STZ. This indicates an improvement in pancreatic B cells as shown by the results of the histological section of the pancreas where an increase in the number and size of islets is observed in diabetic animals having received AELT. These results are in agreement with those obtained by authors.[39,40] The increase in the activity of antioxidant enzymes is thought to be due to the presence of flavonoids in the AELT. Indeed, flavonoids are able to increase the synthesis of endogenous antioxidants and/or the activity of SOD.[41]

7. Conclusions

The oral administration of AELT can improve chronic hyperglycemia and dyslipidemia, and protect tissues of T1DM rats against damage induced by oxidative stress. These different pharmacological properties are thought to be due to the phytoconstituents presents in the AELT. This study provides evidence for the ethnobotanical use of AELT as a treatment for diabetes mellitus. To complete this work, more in-depth and detailed studies will be performed later to isolate and identify the main active compounds and their mechanisms of action.

8. Source of Funding

None.

9. Conflict of Interest

The authors declare that they have no conflicts of interest.

Acknowledgments

The authors are grateful to the Laboratory of Medicinal Plants, Health and Galenic Formulation at the University of Ngaoundere (Cameroon) and Laboratory of Life and Earth Sciences of the University of Maroua (Cameroon) for providing the facility to carry out the research.

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Cite this article: Rosine BT, Fidèle N, David M. MPharmacological potential of *Lactura taraxacifolia* leaf on blood glucose levels, lipid profile, and oxidative stress parameters in diabetic rats. *J Pharm Biol Sci* 2022;10(1):29-36.