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Anti-diabetic activities of *Chromolaena odorata* methanol root extract and its attenuation effect on diabetic induced hepatorenal impairments in rats

Oluyemisi Omotayo Omonije*, Abubakar Ndaman Saidu and Hadiza Lami Muhammad

Abstract

Background: *Chromolaena odorata* is a medicinal plant whose root has not been reported for detailed anti-diabetic properties. Hence, **t**his study investigated the anti-diabetic properties of the methanol root extract of *Chromolaena odorata* and its effect on biochemical parameters in alloxan induced diabetic rats.

Methods: In-vitro studies were carried out using α-amylase inhibition, glycosylated heamoglobin inhibition and glucose uptake test in yeast cells. Twenty (20) alloxan (120 mg/kg bw) induced diabetic rats were divided into 4 groups and treated with 0, 300 and 600 mg/kg bw of the extract and 5 mg/kg b.wt glibenclamide respectively. All treatments were administered daily for 14 days through oral route with the aid of esophageal cannula. Five (5) rats were also set up as normal control. Serum biochemical parameters were analysed.

Results: *Chromolaena odorata* exhibited strong inhibition of α-amylase activity and glycosylated heamoglobin with IC_{50} values; 533.05 μg/ml and 679.12 μg/ml respectively Extract doses of 300 and 600 mg/kg bw exhibited 49.86% and 68.30% in vivo hypoglycemic effect and increase the weight gain of animals to 13.23 ± 0.67 g and 13.87 ± 0.67 g respectively. The concentrations of sodium, chloride, bicarbonates, aspartate transaminase (AST), alkaline phosphatase (ALP) and total proteins were significantly ($p < 0.05$) elevated while albumin, direct and total bilirubins were lowered in diabetic untreated rats when compared with the control Treatment with extract at 300 and 600 mg/kg bw significantly ($p < 0.05$) restored the concentrations of AST, ALP, albumin, total proteins, direct and total bilirubins towards their normal levels but could not significantly ($P > 0.05$) attenuate the elevated sodium, chloride, bicarbonates, urea and creatinine concentration when compared with the untreated control.

Conclusion: *Chromolaena odorata* root extract exhibited anti-diabetic and protective effect against diabetic induced hepatic impairment. However, diabetic induced renal impairment was not attenuated by treatment with *Chromolaena odorata* in rats.

Keywords: *Chromolaena odorata*, Anti-diabetics, Biochemical parameters, α-Amylase

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Introduction

Diabetes mellitus (DM) is a diverse and complex metabolic disorder that occurs due to the disturbances in fat, proteins and carbohydrate metabolism in response to insulin deficiency or insensitivity [1]. The world health organization estimated a total 150 million people on global basis suffer from diabetes and this likely tends to increase to 300 million before 2025. It was also documented that 8.5% of adult's population in 2014 are diabetes, and about 1.6 million diabetes associated deaths occur in 2016 [2]. The dilemma of diabetes complications also take a great burdened on global expenditure. In 2015, 12% of the global health expenditure was spent on diabetes [3]. About 376 billion USD in form of diets, medicines, research, training etc. was spent on diabetes mellitus and this global expenditure is expected to reach 490 billion USD in 2030 [4]. The current drug therapies including biguanides, α-glucosidase inhibitors, sulfonylureas and glinides are synthetic and are besieged with limitations in terms of cost, safety and efficacy [8].

Natural products are rich sources of medicinal/therapeutic agents and have been use since centuries for management or treatment of diseases and maintenance of good health. Decades of scientific research has also validated the medicinal claim of these natural products against several diseases [5–8]. It is therefore reasonable to extend our search for better alternative anti-diabetics from natural products that are commonly used in traditional medicine,

Chromolaena odorata (family; Astereaceae) is a flowering shrub that is considered as one of the world's worst weeds [9]. *Chromolaena odorata* parts have been used in African folk medicine for varieties of ailments including dysentery, malaria, toothache, diarrhoea, fever, skin diseases and diabetes [10–12]. *Chromolaena odorata* has also been reported for several pharmacological properties including antimalerial, anthelmintic, analgesic, anti-antipyretic, inflammatory, antispasmodic, antigonorrheal, antioxidant, insecticidal, antimycobacterial, fungicidal, diuretic, wound healing, blood coagulation and antibacterial [13–15]. The leaves have also been reported for anti-diabetic properties [9]. However, no known anti-diabetic activity of the whole root extract has either been done in vivo or in vitro. Hence, this study investigated the anti-diabetic properties of the methanol root extract of *Chromolaena odorata* and its effect on biochemical parameters in alloxan induced diabetic rats.

Materials and methods

Sample preparation and extraction

Fresh whole root sample of *Chromolaena odorata* was collected in March 2016 at Federal University of Technology Staff School garden, Minna, Niger state, Northern Nigeria. The roots were thoroughly washed under running tap water to remove all contaminants after which they were cut into pieces, dried for 2 wk. (37 oC) and finally grounded using a grinder mill. A 50 g of the plant material was extracted with 200 mL of methanol using soxhlet apparatus and the resulting extract was concentrated using rotary evaporator.

Chemicals and reagent

Alpha-amylase from *Aspergillus oryzae* was a product of Sigma-Adrich Co., St Louis, USA, while methanol was a product of Merck, Germany. Randox Liquizyme assay kits (AST, ALT, ALP, Total proteins, albumin, urea) and Spectrun diagonistic kits (sodium, chloride and bicarbonates) were used to determine the biochemical parameters. Other chemicals and reagents were of analytical grade and were also obtained from Sigma-Adrich Co., St Louis, USA,

Alpha amylase inhibition assay

Alpha-Amylase inhibitory activity of the extract was determined at concentrations of 200–1000 μg/mL using potato starch solution substrate as described by Nickavar and Yousefian [16]. The α-amylase inhibitory activity of the extract was calculated using the formular below [17].

$$\text{The } \alpha\text{-amylase inhibitory activity} = \frac{[(\text{Ac}+) - (\text{Ac}-)] - [(\text{As-Ab})] \times 100}{[(\text{Ac}+) - (\text{Ac}-)]}$$

Where, Ac + = Absorbance of 100% enzyme activity (only solvent with enzyme).

Ac- = Absorbance at Zero % (0%) enzyme activity (only solvent without enzyme).

As = Absorbance of test sample (with enzyme).

Ab = Absorbance of blank (a test sample without enzyme).

Non-enzymatic glycosylation of haemoglobin method

Adult albino rats were anesthetized under diethyl ether, and the blood sample was collected and transferred into ethylenediaminetetraacetic acid (EDTA) bottle [18]. Blood haemolysate was prepared based on the principle of hypotonic lysis according to the method of Asgary et al., [19]. Effect of whole root extract of *Chromolaena odorata* (200 μg/ml - 1000 μg/ml) on the degree of glycosylation of haemoglobin was measured colorimetrically at 520 nm [20]. Metformin was used as a standard drug for assay and percentage inhibition was calculated using the formula,

$$\%\text{Inhibition} = \frac{\text{Absorbance Sample} - \text{Absorbance Control} \times 100}{\text{Absorbance Sample}}$$

Glucose uptake by yeast cells

Ability of the extract at various concentrations (200–1000 μg/mL) to enhance glucose uptake into *Saccharomyces cerevisiae* cells was determined using the method described

Table 1 Alpha Amylase Inhibitory Activity of Methanol Extract of *Chromolaena odorata* Whole Root

Concentration (µg/ml)	% Inhibition (standard)	IC_{50}value	% Inhibition (test sample)	IC_{50}value
200	28.81 ± 1.50^{a}		25.54 ± 2.23^{a}	
400	43.19 ± 1.96^{b}		43.43 ± 0.23^{b}	
600	65.44 ± 2.06^{c}	446.86 µg/ml	54.43 ± 3.12^{b}	533.05 µg/ml
800	84.88 ± 2.93^{d}		67.52 ± 3.26^{b}	
1000	92.18 ± 2.86^{d}		81.82 ± 3.54^{c}	

Values are mean ± SEM of triplicate determinations. Values along the same column with different superscripts are significantly different ($p < 0.05$)

by Mary and Gayathri [21]. Metformin was also used as standard. The percent increase in glucose uptake by yeast cells was calculated using the following formula:

$$\text{Increase in glucose uptake } (\%) = \frac{\text{Abs control} - \text{Abs sample} \times 100}{\text{Abs control}}$$

Where, Abs control is the absorbance of control reaction (containing all reagents except the test sample) and Abs sample is the absorbance of test sample.

In vivo studies

Experimental animal

Healthy albino rats of average weight (134.87 ± 3.23) g were obtained from animal holding unit, Federal University of Technology, Minna, Niger State Nigeria. The rats were maintained under laboratory condition of temperature and humidity with 12 h light and dark sequence. They were allowed access to rat pellets and water ad-libitum.

Acute toxicity study

The median lethal dose (LD_{50}) of the methanol extract of root of *Chromolaena odorata* was determined by administering the extract to six groups of animals at doses of 10, 100, 1000, 1600, 2900 and 5000 mg/kg bw respectively according to the method of Lorke (1983), as described by Amos et al. [22]. A control group was also set up comprising of 3 rats and was given 2 ml/kg bw normal saline. All extract were administered to animals once orally using esophageal cannula. The animals were observed for any adverse effect and mortality within 24 h of treatment and after a week.

Table 2 Inhibition of Haemoglobin Glycosylation by *Chromolaena odorata*

Concentration (µg/ml)	%Inhibition (standard)	IC_{50} Value	%Inhibition (sample)	IC_{50} Value
200	31.13 ± 2.55^{a}		22.01 ± 2.28^{a}	
400	44.16 ± 1.86^{b}		36.51 ± 2.93^{b}	
600	56.38 ± 1.75^{c}	506.08 µg/ml	49.55 ± 2.34^{c}	679.12 µg/ml
800	70.30 ± 2.66^{d}		55.05 ± 2.34^{c}	
1000	74.44 ± 3.24^{d}		65.99 ± 2.87^{c}	

Values are mean ± SEM of triplicate determinations. Values along the same column with different superscripts are significantly different ($p < 0$)

Table 3 Glucose Uptake Enhancement Activity of *Chromolaena odorata*

Concentration (µglml)	Sample%Uptake At 5 mM	Sample %Uptake At 10 mM	Sample %Uptake At 25 mM
200	45.71 ± 1.61^{a}	29.04 ± 2.10^{a}	19.66 ± 1.55^{a}
400	45.88 ± 1.24^{a}	31.85 ± 2.23^{a}	21.32 ± 1.53^{a}
600	56.76 ± 2.68^{a}	37.47 ± 2.03^{ab}	25.14 ± 1.17^{a}
800	61.76 ± 2.2^{b}	46.55 ± 1.68^{b}	33.27 ± 1.51^{b}
1000	73.24 ± 1.26^{a}	58.72 ± 1.74^{c}	38.51 ± 1.66^{c}

Values are mean ± SEM of triplicate determinations. Values along the same column with different superscripts are significantly different ($p < 0.05$)

Anti-diabetic study

Twenty (20) albino rats were intra-peritoneally administered a freshly prepared solution of alloxan monohydrate (120 mg/kg) to overnight fasted rats. Diabetic state was confirmed by glucose level above 200 mg/kg bw [23]. The animals were divided into 4 groups and were treated with 2 ml/kg of normal saline, 300 mg/kg, 600 mg/kg bw extract and 5 mg/kg b.wt glibenclamide. All treatments were administered daily through oral route for 14 days. Five (5) rats were also set up as normal control. The blood glucose level was checked and the weight taken after every 3 days. On the fifteenth day animals in all group were euthanized and blood samples were collected and prepared to extract the serum according to the method described by previous studies [18, 24].

Biochemical parameters

Standard methods were used for estimation of aspartate aminotransferase, Alanine Aminotransferase [25], alkaline phosphatase activity [26], total protein concentration [27], albumin, total and direct bilirubin concentration [28] in the serum of the animals. The concentration of potassium, chloride, soduim and bicarbonate were evaluated using standard procedures [29] while urea and creatinine

Table 4 Acute toxicity profile of methanol root extract of *Chromolaena odorata*

Doses (mg/kg bw)	Mortality	Physical obervation
10	0/3	No sign of toxicity
100	0/3	No sign of toxicity
1000	0/3	No sign of toxicity
1600	0/3	No sign of toxicity
2900	0/3	weakness
5000	0/3	Weakness, redness of the eye

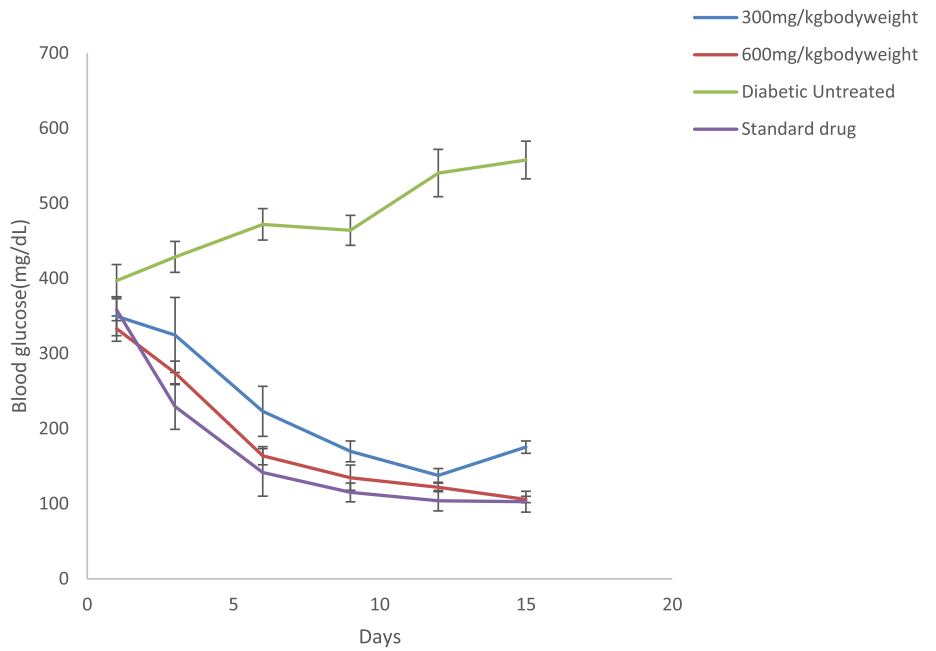

Fig. 1 Effect of *Chromolaena odorata* whole Root Methanol Extract on Blood Glucose Level

concentrations were evaluated according to the methods of Burtis et al., [30] and Heinegard and Tinderstrom, [31].

Statistical analysis

Data were analyzed using Statistical analysis system (SAS) and presented as means ± SEM. Comparisons between different groups were carried out by one way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test (DMRT). The level of significance was set at $P < 0.05$ [32].

Results

In vitro anti-diabetic activity of the extract

There was a dose-dependent significant ($p < 0.05$) increase in invitro anti-diabetic activities of *Chromolaena odorata* methanol whole root extract (Tables 1, 2 and 3). The extract inhibited α-amylase activities with IC_{50} value of 533.05 μg/ml which is comparable to the standard drug (Acarbose) with an IC_{50} value of 446.86 μg/ml (Table 1). The extract also inhibited non-enzymatic glycosylation of heamoglobin with IC_{50} value of 679.12 μg/ml while the standard drug had IC_{50} value of 506.08 μg/ml (Table 2). The extract also enhance glucose transport in a dose dependent manner (Table 3).

Acute toxicity

Acute toxicity studies revealed that the administration of methanolic extract (up to a dose of 5000 mg/kg b.wt) of *Chromolaena odorata* did not produce significant changes in behaviour of the animals. No death was observed and hence LD50 > 5000 mg/kg bw (Table 4).

Anti-diabetic properties of *Chromolaena odorata* whole root methanol extract

Administration of methanol root extract of *Chromolaena odorata* to diabetic rats caused a progressive and dose dependent decrease in blood glucose level with percentage glucose reduction of 49.86% and 68.30% at doses of 300 and 600 mg/kg bw respectively, while the gilbenclamide (standard drug) caused 71.41% blood glucose when compared to the diabetic untreated rats (Fig. 1). The extract at doses of 300 and 600 mg/kg bw had weight gain of 13.23 ± 0.67 g and 13.87 ± 0.67 g respectively when compared with untreated control which had

Table 5 Effect of *Chromolaena odorata* on body weight of Diabetic treated albino rats

	Day 1	Day3	Day6	Day9	Day12	Day15	Weight gain (g)
300 mg/kg	175.67 ± 8.52	176.67 ± 6.00	179.33 ± 6.48	181.00 ± 6.11	184.65 ± 7.63	188.90 ± 5.56	13.23 ± 0.67
600 mg/kg	185.34 ± 24.45	187.56 ± 3.43	189.45 ± 2.48	191.68 ± 7.57	195.78 ± 11.80	199.21 ± 11.24	13.87 ± 0.67
Diabetic untreated	178.00 ± 25.38	177.33 ± 26.02	175.33 ± 26.44	173.67 ± 25.14	168.98 ± 21.56	170.77 ± 17.14	−8.23 ± 0.34
Standard	152.00 ± 14.73	155.67 ± 15.35	159.00 ± 15.27	161.33 ± 15.38	164.87 ± 12.45	167.73 ± 11.32	15.73 ± 0.87

Values are mean ± SEM of 3 determinations

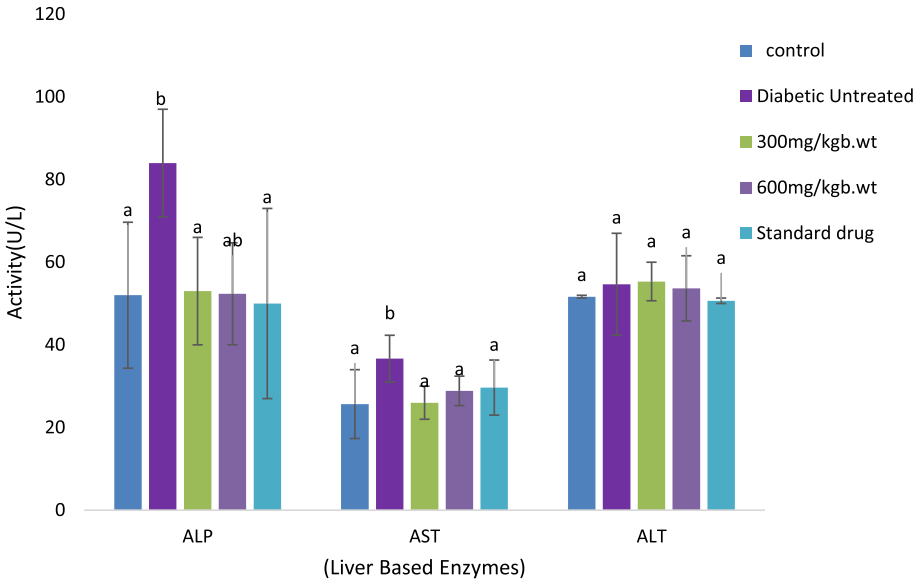

Fig. 2 Effect of Methanol Root Extract of *Chromolaena odorata* on Liver based enzymes (ALP, AST, and ALT) in Alloxan Induced Diabetic Rats. Each bars represents Mean ± SEM of triplicate determinations. Bars with different alphabets indicate significant difference at ($p < 0.05$). ALP-Alkaline Phosphatase, AST-Aspartate Aminotransferase, ALT-Alanine Aminotransferase

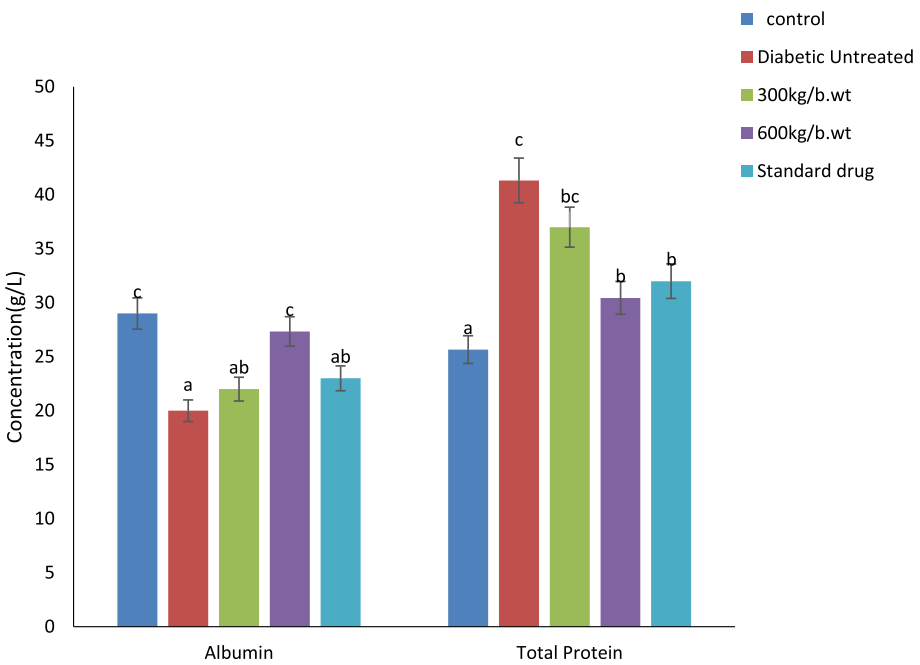

Fig. 3 Effect of Methanol Root Extract of *Chromolaena odorata* on Serum Albumin and Total Proteins in Alloxan Induced Diabetic Rats. Each bars represents Mean ± SEM of triplicate determinations. Bars with different alphabets indicate significant difference at ($p < 0.05$)

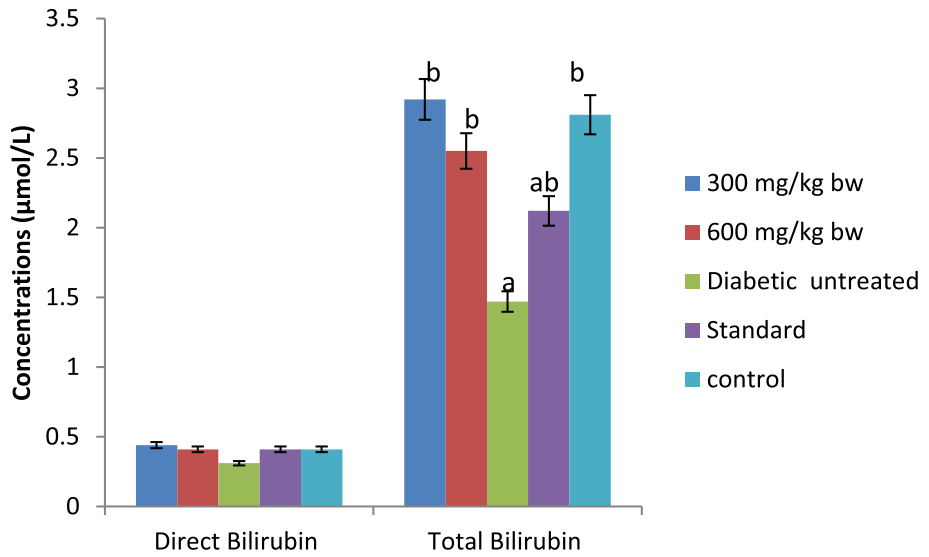

Fig. 4 Effect of Methanol Root Extract of *Chromolaena odorata* on Serum Bilirubins in Alloxan Induced Diabetic Rats. Each bars represents Mean ± SEM of triplicate determinations. Bars with different alphabets indicate significant difference at ($p < 0.05$)

significant ($p < 0.05$) decrease in body weight (− 8.23 ± 0.34 g). However, rats treated with glibenclimide had weight gain of 15.73 ± 0.87 g (Table 5).

Biochemical parameters

Enzymes

The activities of serum aspartate aminotransferase and alkaline phosphatase (ALP) were significantly ($p < 0.05$) elevated in diabetic untreated rats when compared to the control group. Administration of methanol roots extracts of *C. odorata* and standard drug caused a significant reduction in these ALP and AST activities when compared with the untreated control, these enzyme activities in treated group were comparable ($p < 0.05$) the activities in the control group. However, there was no significant ($p < 0.05$) different in the activity of Alanine aminotransferase in the treated and the untreated groups when compared to the control group (Fig. 2).

Albumin, total proteins and bilirubins

There was a significant ($p < 0.05$) increase in the concentration of total proteins and a decreases in albumin concentrations in the diabetic untreated rats when compared to those of the control group. The administration of the extract (300 and 600 mg/kg bw) and the standard drug caused a significant ($p < 0.05$) reduction and significant ($p < 0.05$) increase in the concentrations of total proteins and albumin respectively (Fig. 3). The diabetic untreated rats have significantly ($p < 0.05$) low levels of direct and total bilirubins when compared to the control. Treatments with 300 and 600 mg/kg bw of *C. odorata* root extract significantly ($p < 0.05$) increase the levels of these biliubins comparable to the normal control (Fig. 4).

Urea, creatinine and electrolyte

The serum concentration of electrolytes including sodium, chloride and bicarbonates were significantly ($p < 0.05$) higher in diabetic untreated rats when compared with the normal control. Unfortunately, treatments with methanol root extracts of *Chromolaena odorata* (300 and 600 mg/kg bw) as well as treatments with glibenclimide did not cause any significant ($p > 0.05$) attenuation to the elevated levels of these electrolytes that were seen in the untreated control (except for chloride concentration in glibenclimide treated rats which was comparable with the normal control). However, no significant difference ($p < 0.05$) exist in potassium concentrations among all the experimental as well as the control group (Fig. 5). Similarly there was no reduction in the diabetics induced elevated levels of urea and creatinine in rats administered methanol root extracts of *Chromolaena odorata* (300 mg/kg bw) when compared with the untreated control. Howevr, 600 mg/kg bw of the extract only manage to significantly ($p < 0.05$) decrease the urea concentrations when compared with untreated group (Fig. 6).

Discussion

Alpha-amylase is an important enzyme that hydrolyzes dietary starch during carbohydrate metabolism. In the present study, the potent inhibitory effects of *Chromolaena odorata* methanol root extract on α-amylase activity is an indication that this plant would be beneficial in keeping the blood glucose level low by delaying the digestion of carbohydrate and thus reduce the concentration of postprandial plasma glucose. This inhibitory activity of the extract could be attributed to the presence

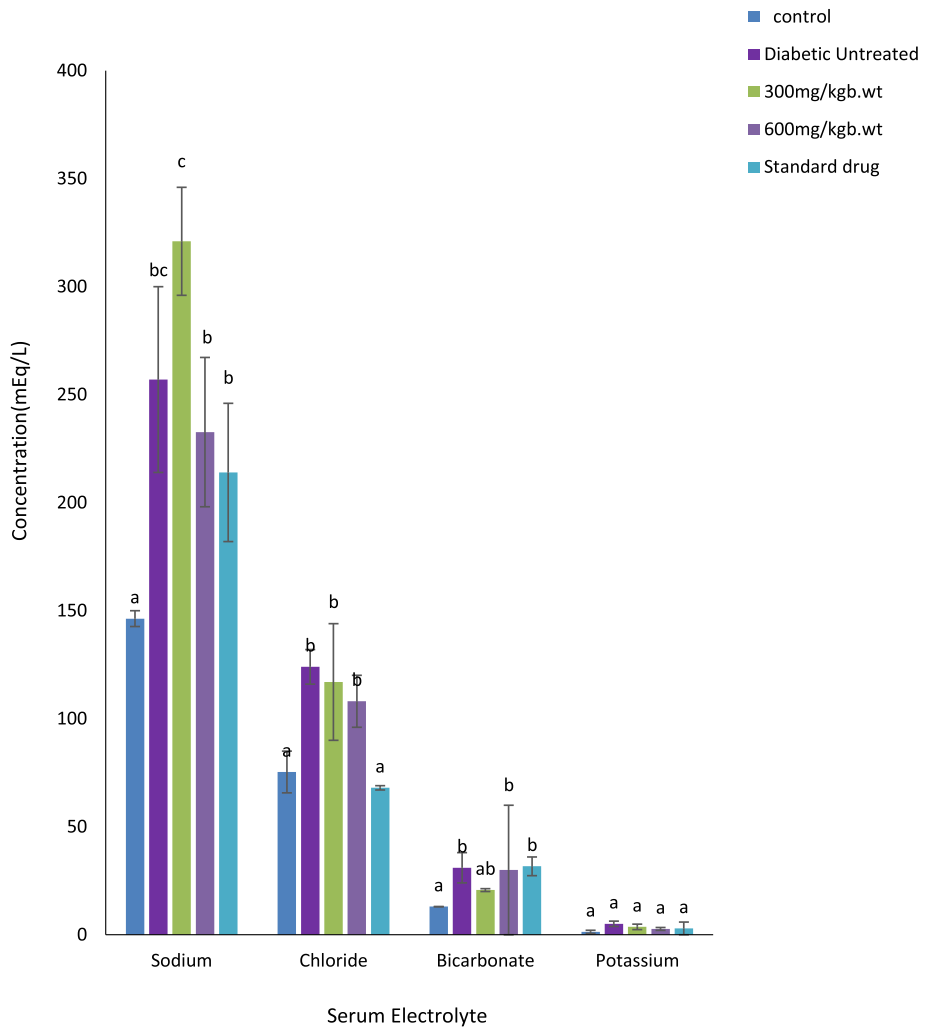

Fig. 5 Effect of Methanol Root Extract of *Chromolaena odorata* on Serum Electrolyte in Alloxan Induced Diabetic Rats. Each bars represents Mean ± SEM of triplicate determinations. Bars with different alphabets indicate significant difference at ($p < 0.05$)

of antioxidants phytochemicals including; flavonoids, tannins and saponins which have been reported to inhibit α-amylase activity and preserve the β-cell integrity thus protect against the development of insulin resistance type 2 diabetics [33].

Bamisaye et al. [9] reported that *Chromolaena odorata* has several medicinal properties due to the presence of high amount of flavonoids and tannins in the plant. Previous study by Phan et al. [11] also reported that *Chromolaena odorata* contains high amount of phenolic compounds that protect against oxidative damage.

Formation of glycated end products (glucose-hemoglobin complex) serves as a source of free radicals which inturn results in oxidative stress that complicate diabetes mellitus. In this study, methanol root extract of *Chromolaena odorata caused appreciable* inhibition of glycated hemoglobin formation with an IC_{50} value of 679.1 μg/ml. This is an indication that the extract could be useful in prevention of diabetes induce oxidative stress. This inhibitory effect of the extract could be credited to the presence of some non-phenolic metabolites that acted as enzyme inhibitors, exhibiting an additive or synergistic effect with the phenolics present in the sample [34]. The ability of the extract to enhance glucose transport (Table 3) could be attributed to the presence of tannin and saponin which have been reported to enhance transportation and expression of GLUT 4 respectively [35].

A preliminary toxicity study of the extract showed that in single dose the plant extract had no adverse effect up to concentration of 5000 mg/kgb.wt. This corroborated the report by Ogbonna et al., [36] that *C. odorata* showed no toxicity effect on mice up to 5000 mg/kg b.wt. The significant ($p < 0.05$) blood glucose lowering effect of *Chromolaena odorata* methanol root extract may be attributed to the presence of phenols, flavonoids,

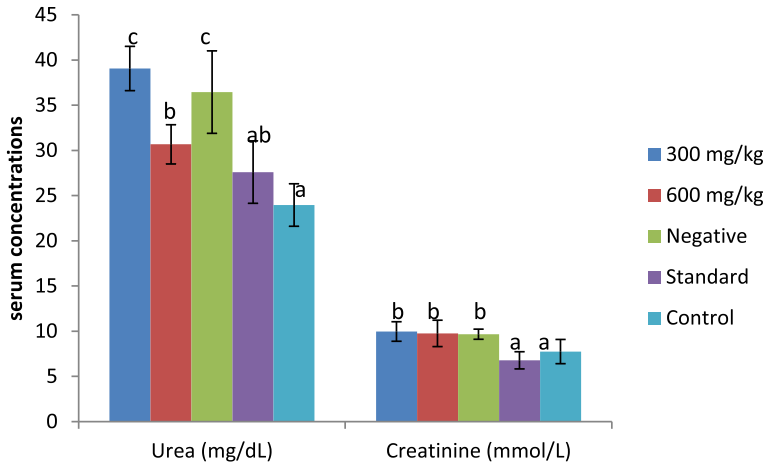

Fig. 6 Effect of Methanol Root Extract of *Chromolaena odorata* on Serum Urea and Creatinine in Alloxan Induced Diabetic Rats. Each bars represents Mean ± SEM of triplicate determinations. Bars with different alphabets indicate significant difference at ($p < 0.05$)

alkaloids, tannins, and saponins that have been associated with hypoglycemic activity [37, 38]. Leaves of *C. odorata* were also reported by Ijioma et al., [39], to be hypoglycemic. During diabetic conditions, insulin deficiency prevents the body from the utilization of glucose for energy source. Thus the body switched to the stored fats and muscle proteins, leading to the reduction in overall body weight as observed in untreated groups. The anti-diabetic activity of *Chromolaena odorata* methanol root extract is also supported by the significant weight gain of the treated animals in comparison with the untreated animals. This shows the improvement in metabolic activity of the treated animals.

Hepatic impairment is one of the complications of diabetes mellitus and its evident by elevation of serum transaminase and alkaline phosphatases activities. Therefore, evaluation of serum enzymes biomarker will provide reliable indicator of functional integrity of the liver as well as treatment outcome [40–42] in diabetic condition. In the present study, the elevated levels of serum aspartate aminotransferase and alkaline phosphatase activities in diabetic untreated rats is an indication of plasma membrane and hepatic impairment, these will adversely hampered amino acid and carbohydrates metabolism and thus effect ATP production [43]. The observation with ALT activities is an indication that diabetes selectively effect transaminases activities since only AST activity was altered and not ALT [44]. Administration of methanol roots extract of *C. odorata* and standard drug caused a significant restoration of the plasma membrane and liver functional integrity as evident by decrease ALP and AST activities.

The total proteins, albumin and bilirubins play major roles in assessing the integrity of kidney and liver [45]. The observed increases in the total proteins concentrations in diabetic untreated rats could be attributed to the elevation of various acute phase proteins, globulins and fibrinogen in diabetes mellitus [46]. In concordances with this finding, Ladei et al., [47] reported increased plasma levels of acute phase proteins in type 1 and type 2 diabetes adult patients. The increase in total proteins reported in this study could lead to dehydration which is injurious to cellular homeostasis. This will harmfully compromised the normal metabolic activities of the liver and consequently the health of the animals [48]. The significant decreases in albumin concentration in diabetic untreated rats could be attributed to fact that albumin are involve in glycation (Hemangi & Bhonlet [49]. It was observed that methanol extract of *Chromolaena odorata* root enhance adequate glucose regulation thereby reducing glycated albumin which is responsible for the higher level of albumin concentration in the diabetic treated group. This finding is supported by the significant inhibitory activity of the extract against heamoglobin glycosylation as reported above (Table 3).

Bilirubin is an endogenous anion product of hemoglobin degradation of the red blood cell. The low level of direct and total bilirubin in diabetic untreated control, this is an indication of impair liver function as reported by Libor, [50]. The improvement in the concentrations of direct and total bilirubin in rats treated with *C. odorata* (300 and 600 mg/kg bw is an indication of increase glucose mobilization into cells leading to more efficient glucose utilization [51].

Plasma electrolytes, creatinine and urea concentrations are useful clinical indicators of renal integrity [18]. Creatinine is a waste product of muscle metabolism while urea is a byproduct of protein metabolism. During renal impairment, the excretion of these metabolites by the kidney is altered and thus accumulates in the plasma [45]. The observed significant increase in serum urea and creatinine concentrations in diabetic rats is an

indication of renal impairment. The diseases condition must have either altered the metabolism of creatinine leading to increased synthesis or decrease tubular excretion [52]. These findings corroborated with the studies by Aldler et al. [53] and Judykay et al., [54] which showed that raised plasma urea levels in diabetic patients may indicate a pre-renal problem. Furthermore, the significant alterations in the concentrations of sodium, chloride and bicarbonate suggest that the integrity of renal tubules as regards to the excreation and maintenances of normal levels of these electrolytes in the system of the animal have been compromised [18]. Unfortunately, treatment with *Chromolaena odorata* resulted does not bring about any significant ($p > 0.05$) attenuation in the concentrations of urea, creatinine and electrolytes, hence the functional integrity of kidney cannot be preserved by treatment with *Chromolaena odorata* in diabetic rats.

Conclusion

Chromolaena odorata root extracts exhibited anti-diabetic properties both in vitro and in vivo models. The extract exhibited protective effect against diabetic induces hepatic impairment. However, the functional integrity of kidney cannot be preserved by treatment with *Chromolaena odorata* in diabetic rats.

Abbreviations

ALB: Albumin; ALP: Alkaline Phosphatase; ALT: Alanine transaminas; ANOVA: Analysis of variance; AST: Aspartate Transaminase; *C. odorata*: *Chromolaena odorata*; CRT: Creatinine; TP: Total proteins

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Authors' contributions

This work was carried out in collaboration between all authors. Authors OOO, ASN and HLM design the work. Authors OOO carried out the practical work, did the literature search, data analysis and preparation of the manuscript. Author ASN and HLM supervised the work and participate in data analysis and writing of the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethics approval

The principles governing the use of laboratory animals as laid out by the Federal University of Technology, Minna Committee on Ethics for Medical and Scientific Research and also existing internationally accepted principles for laboratory animal use and care as contained in the Canadian Council on Animal Care Guidelines and Protocol Review were duly observed.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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