

Investigation of the Effect of Aqueous Leaf Extract of *Senna alata* (L) Roxb on Palm Oil- Induced Hyperlipidaemic Plasma Lipid in Wister Rats

B. M. Onyegeme-Okerenta*, T. Nwosu and M. O. Wegwu

Department of Biochemistry, University of Port Harcourt
PMB 5323, Port Harcourt, Nigeria

*Corresponding author

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Abstract

This research investigated the hypolipidaemic effect of *Senna alata* (L) Roxb in palm oil-induced elevated plasma lipid level in Wister rats. Acute toxicity test was carried out on the leaves of *S. alata* (L) Roxb (L) Roxb. Thirty-five male Wister rats were grouped in seven, with five in each group: Group 1 was fed normal animal diet for 42 days, while Groups 2 to 7 were fed palm oil-rich diet for the 42 days. However, groups 3 to 7 were treated with the aqueous extract from day 22 to 42, with the following respective doses: 500mg/kg, 1000mg/kg, 2000mg/kg, 3000mg/kg and 4000mg/kg body weights. Group 2 (negative control) was not treated. On day 43, after an overnight fast, the rats were slaughtered anaesthetically; and their blood samples and organs (kidneys, livers, and hearts) were taken for analyses. Total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglyceride (TG); liver function tests (LFT) and histological analyses of the organs were carried out. The result showed that the palm oil-rich diet significantly ($p<0.05$) elevated the TC, TG, and LDL levels in group 2 compared to group 1 (normal control), while decreasing the HDL levels in group 2 compared to group 1. However, the extract significantly ($p<0.05$) reduced the TC, TG and LDL levels in the plasma of groups 3 to 7, while significantly increasing the plasma HDL level in group 7; when compared to that

of group 2. A significant ($p < 0.05$) reduction in the weight, in a dose-dependent pattern was observed. The LFT result showed that AST, ALT and ALP were reduced in groups 3 to 7 compared to group 2, while ALP and ALT were significantly reduced ($p < 0.05$) when treated with 4000mg/kg body weight. The extract showed no significant effect on bilirubin levels. The photomicrographs of some organ's histology showed no effect on the kidneys in all groups. Group 2 showed mild vascular congestion while other groups showed no effect to the hearts. The liver of group 1 showed no effect; group 2 and 3 showed severe fatty change and inflammation, though lesser in group 3; groups 4 and 5 showed milder fatty change and inflammation; while groups 6 and 7 showed almost no effect in their liver. Acute toxicity test showed toxicity of the extract at 5000mg/kg body weight. This study, therefore, demonstrates that the leaf of *S. alata* (L) Roxb possesses significant hypolipidaemic properties and may, thus, be used in treating hyperlipidaemia.

Keywords: *Senna alata* (L) Roxb, acute toxicity, hyperlipidaemia, palm oil, histology

Introduction

Hyperlipidaemia is abnormally elevated plasma lipids (cholesterol, cholesterol esters, phospholipids, and triglycerides) or lipoproteins, known as hyperlipoproteinaemia (Blood *et al*, 2007). A type of lipoprotein known as Low-density lipoproteins (LDL) distributes fat molecules throughout the body, while high-density lipoproteins (HDL) extract fat molecules from body cells back to the liver. Elevated LDL and reduced level of HDL are linked to atherosclerosis, a risk factor for cardiovascular diseases (CVD). This is because low plasma level of HDL will be inadequate to remove excess lipid from LDL, which when oxidised, is phagocytized by macrophages and clog the arteries, consequent upon which atherosclerosis develops. Atherosclerosis is a condition which affects the arteries due to a long term leukocytic response to inflammation in the arteries, propelled by elevated plasma LDL levels, without substantial extraction of lipids by active HDL. Research shows that excessive saturated fat consumption can elevate the plasma lipid level which can develop into hyperlipidaemia, a known risk factor for certain cardiovascular diseases (Cannon and O'Gara, 2007). Some foods contain a high amount of saturated fatty acids, such foods include butter, cheese, fatty meat, and whole milk (American Heart Association, 2014). Some vegetable oils also contain high saturated fatty acids, they include palm kernel oil, coconut oil, and palm oil (USDA, 2015).

Many indigenous plants in Nigeria have been used in folkloric medicine in treating several diseases. Parts of these plants (roots, bark, stem, leaves, flower, etc.) used to make local drugs have such biological properties as hypolipidaemic, antimicrobial, and anti-inflammatory, amongst others. Also in treating fever, cough, snake bites, etc. With various reports of the deleterious effects posed by synthetic drugs, more research into sources of natural drugs, like medicinal plants,

seems inevitable so as to understand the biochemical basis of their pharmacological activities for better and safer drug production.

S. alata (L) Roxb is a tropical shrub, but can also thrive in temperate climes. It belongs to the Fabaceae family. It can grow up to 16ft tall, branched. However, it can stand at 30ft tall, if straight. The large pinnate leaves are up to 30inches in length consisting of 7-14 smooth pairs of leaflets, each about 3in long and 1-4in in width. The yellow flowers, shaped like a cup, are closely-packed on a straight spike, looking like a candlestick (from where the name was obtained). *S. alata (L) Roxb* is an ornamental and medicinal plant (Adedayo *et al.*, 2001) used in folkloric medicine in treating various ailments. Studies have reported the use of *S. alata (L) Roxb* leaves in treating abdominal pain, constipation, and liver abnormalities (Hennebelle *et al.*, 2009); others include eczema, skin inflammation, rashes on the skin, athlete's foot, and ringworm (from where the name 'ringworm shrub' was gotten) (Ajibesin *et al.*, 2008).

The hypolipidaemic effects of many plants have been studied and potential remedies identified, however, the search for more potent and safer hypolipidaemic drugs is on the increase and inevitable. The present study is aimed at investigating the hypolipidaemic effect of the aqueous extract of *S. alata (L) Roxb* leaves on palm oil-induced elevated plasma lipid in Wister rats.

Materials and Methods

Sample Collection and Identification

Fresh *S. alata (L) Roxb* leaves were plucked between the 3rd and 6th of December, 2015 from an uncultivated piece of land, by the gate of the University of Port Harcourt, Abuja campus, Choba, Rivers State. The leaves, with voucher number UPH/V/1225, were identified and authenticated by Dr. Chimezie Ekeke of the Department of Plant Science and Biotechnology, University of Port Harcourt, Rivers State.

Preparation of Sample

Fresh leaves of *S. alata (L) Roxb* were air-dried at room temperature ($29\pm 1^{\circ}\text{C}$) for 3 weeks and then ground with the aid of Marlex Excellent grinder (Mumbai, India). The ground sample was then passed through a sieve of 0.5mm pore size to obtain a fine uniform powder.

Preparation of Aqueous Extract

An aqueous sample of the plant extract was prepared by mixing 200g of the powdered leaves with 200ml of distilled water. The mixture was thoroughly stirred and left overnight (about 12 hours) at room temperature, and then filtered. The filtrate was then stored (refrigerated) for subsequent use.

Experimental Design

Thirty-five (35) male Wister rats weighing between 100-150g were procured from the Animal House of the Department of Animal and Environmental Biology, Univer-

sity of Port Harcourt, Choba, Rivers State. The animals were grouped into seven, each group containing five rats. The distribution was such that the mean weights of each group were approximately equal. The animals were acclimatised for 7 days with access to feed and water *ad libitum*, after which the feeding was halted for 6 hours while access to water continued and then their initial weights were measured. Guidelines in animal handling by the National Research Council (NRC, 2011) were duly followed during the process.

Table 1 Animal Treatment Schedule

Groups		Treatment
1	Control	Rats fed with normal diet only, for 42 days.
2	Negative control	Rats fed with Palm oil-rich diet only, for 42 days.
3	500mg/kg	Rats fed with Palm oil-rich diet and treated with 500mg/kg of extract.
4	1000mg/kg	Rats fed with Palm oil-rich diet and treated with 1000mg/kg of extract.
5	2000mg/kg	Rats fed with Palm oil-rich diet and treated with 2000mg/kg of extract.
6	3000mg/kg	Rats fed with Palm oil-rich diet and treated with 3000mg/kg of extract.
7	4000mg/kg	Rats fed with Palm oil-rich diet and treated with 4000mg/kg of extract.

Palm oil-rich diet was prepared by compounding 350g of normal animal feed (Top Feed's growers' mash) with 350ml of palm oil for each concerned group. Administration of extract started from the 22nd day to the 42nd day and was done by gavage. Animals received their doses once a day for 21 days. At the expiration of the 21-day period of treatment (43rd day), after an overnight fast, the animals were weighed and sacrificed anaesthetically by exposure to chloroform vapour for three minutes. Blood samples for each animal were taken in lithium heparin bottles, while the livers, hearts and kidneys were preserved in formalin, in plain bottles.

Acute Toxicity Test

Six groups, each containing four rats, were orally given 500mg/kg, 1000mg/kg, 2000mg/kg, 3000mg/kg, 4000mg/kg, and 5000mg/kg of the extract respectively. They were closely monitored for 24 hours for mortality and general abnormality. At the expiration of the 24 hours, two deaths were observed: seven minutes and thirteen hours thirty-seven minutes after administration of the extract, in the 5000mg/kg group. Other groups recorded no death. Thus, 5000mg/kg was taken to be the LD₅₀ (Toxicology Tutor 2005).

Determination of Lipid Profile

Total Cholesterol, triglycerides, LDL and HDL were analysed by kinetic methods kits from Randox, (United Kingdom) using a double-beam spectrophotometer.

Determination of Liver Enzymes

The animals to be sacrificed were first anaesthetized with chloroform (inhalational anaesthesia) followed by cervical dislocation. Each animal was then placed on a dissecting slab and then cut along the thorax down the abdominal region; blood was collected via cardiac puncture and dispensed into the Heparin bottle for biochemical assays (ALT, AST and ALP). ALT, AST and ALP were analysed by kinetic methods kits from Randox (United Kingdom) using a double-beam spectrophotometer.

Determination of Total and Conjugated Bilirubin

Total and conjugated bilirubin concentration were assayed by kinetic methods kits from Randox, (United Kingdom) using a double-beam spectrophotometer

Histopathological Examination of the Livers, Kidneys and Hearts

Tissue samples for histological studies were fixed in 10% formal saline in labelled plain bottles. The tissues were subjected to standard routine histological procedures as described by Kiernan (2008). The slides were viewed using the light microscope and histopathological changes were observed and recorded at X400 magnification identifying both the normal and the degenerated cells.

Statistical Analysis

Data gathered from this study were all statistically analysed, using One-Way Analysis of Variance (ANOVA). The Statistical Package for Social Sciences (SPSS) version 20.0 (IBM Statistics, UK) was used to analyse the data gathered. All the values were reported as mean $\pm$ standard error of the mean (SEM), and the results were regarded significant at $p < 0.05$, that is at 95% confidence level.

Results and Discussion**Acute Toxicity**

The acute toxicity was determined using LD₅₀. The LD₅₀ result was recorded at 5000mg/kg body weight, which was the exact dose that resulted in 50% mortality of the test animals.

Biochemical Studies

Effect on weight

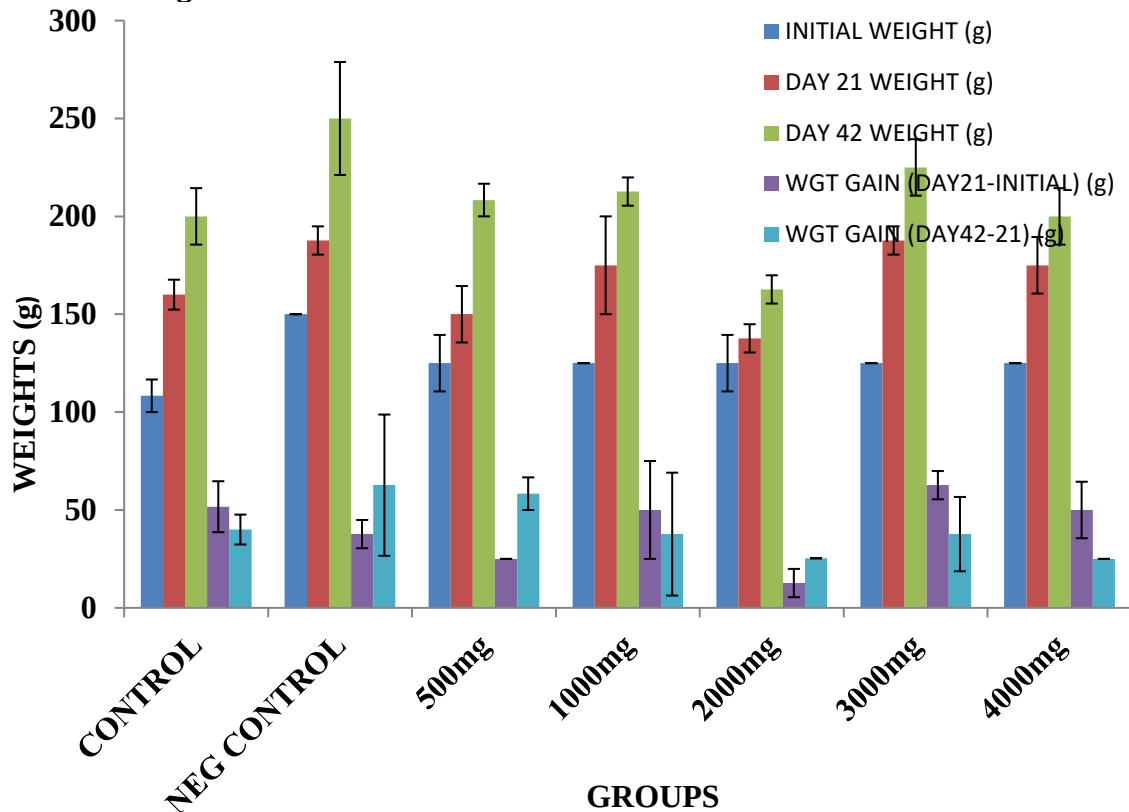


Figure 1: The effect of the aqueous leaf extract of *Senna alata* (L) Roxb on the weights of Wister rats after 21 days treatment

Bars represent values presented as mean $\pm$ SEM (n=3). Bars bearing the same alphabet with the negative control (untreated rats) differ significantly ($p < 0.05$) compared to the negative control. Bars without alphabets are not significantly ($p > 0.05$) different from the negative control. The graph above shows that there was positive growth in all the groups. Their initial weights showed positive progression to day 21, up to day 42; that is through the treatment period. The weight gained between days 21 and 42, which is the treatment period, showed an increase (not significant at $p < 0.05$) from the normal control to the negative control group (untreated group). The negative control group gained the highest weight over the 21-day period. The weight gained showed a progressive decline from the negative control group over the treated groups in a dose-dependent pattern (apart from the 3000mg group). However, no significant ($p < 0.05$) difference between the weight gained in the negative control and the other groups was observed. This showed that the extract may have a mild dose-dependent weight-lowering effect, which agrees with a report by Chichioco-Hernandez and Leonido (2011). The effect of the extract may be due to certain constituents that may have the ability to mobilise triglycerides from adipocytes and facilitate their metabolism.

Effect on Lipid Profile

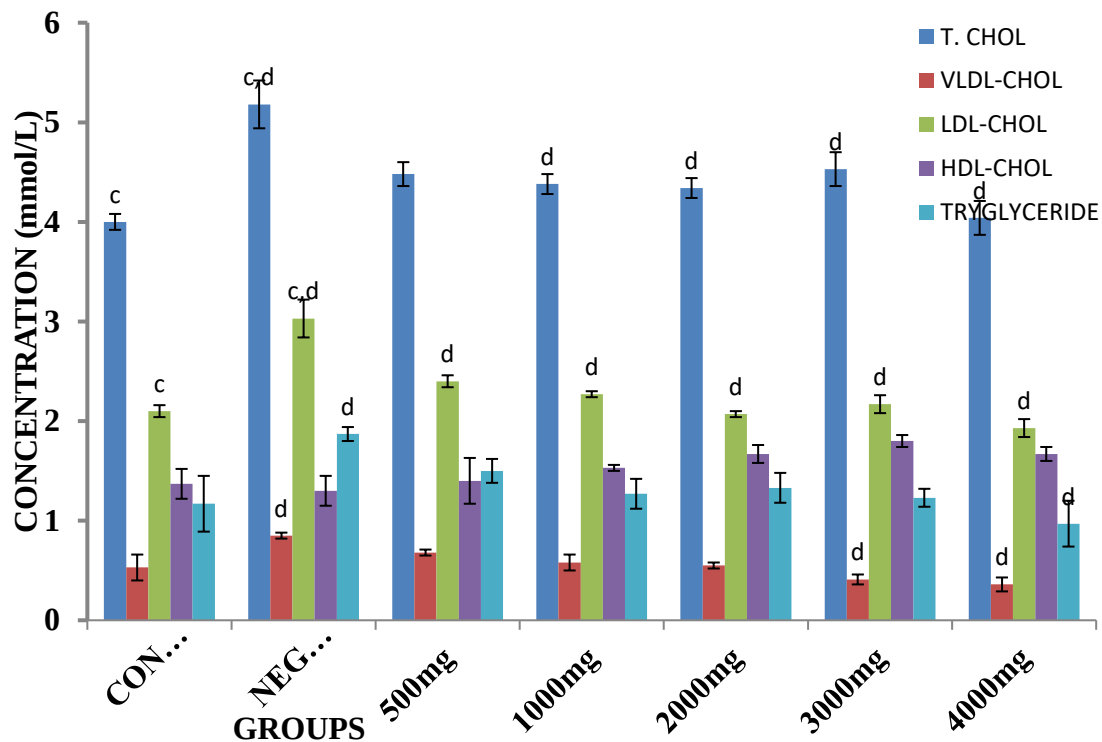


Figure 2: The effect of the aqueous leaf extract of *Senna alata* (L) Roxb on the lipid profile of Palm oil-induced elevated plasma lipid of Wister rats.

Bars represent values presented as mean $\pm$ SEM (n=3). Bars bearing the same alphabet with the negative control (untreated rats) differ significantly ($p < 0.05$) compared to the negative control. Bars without alphabets are not significantly ($p > 0.05$) different from the negative control.

Total Cholesterol

The result on the total cholesterol level of the rats showed that there was a significant difference ($p < 0.05$) between the negative control and all the other groups, except the 500mg group. The result means that the palm oil-rich diet significantly increased the total plasma cholesterol level in the rats after 42 days, which agrees with a report by Clark *et al.* (1997) in the hypercholesterolemic effect of palm oil-rich diet. However, with the administration of different doses of 500mg, 1000mg, 2000mg, 3000mg, and 4000mg per body weight of the extract, in the last 21 days, a significant decrease ($p < 0.05$) was noticed in the total plasma cholesterol, in all the treated groups; except the 500mg group (group 3), which though decreased was not significant ($p > 0.05$). This result shows that *S. alata* (L) Roxb leaf extract is more efficacious than the leaf extract of *Milletia aboensis* in lowering the total plasma cholesterol, which as reported by Onyegeme-okereanta

and Essien (2015), has no significant effect when administered at 500mg, 1000mg, 1500mg, 2000mg and 2500mg per kg b.w.(body weight). The ability of the extract to reduce the total cholesterol levels may not be unconnected with the presence of certain phytochemicals such as catechin (1.1%), saponin (0.52%), and tannic acid (55.26%) reported to lower cholesterol levels (Chung *et al.*, 1998). Saponins sequester cholesterol and bile salts in the intestinal walls, preventing their uptake, thereby enhancing their excretion. This causes the liver to withdraw more cholesterol from circulation to synthesise more bile salts.

Very Low-Density Lipoprotein (VLDL)

In the above Graph, the VLDL result (red bars) showed that while the palm oil-rich diet increased the VLDL levels when comparing the control with the negative control (though not significantly at $p < 0.05$), the extract decreased the VLDL levels in the treated groups, compared to the negative control; but only significantly ($p < 0.05$) in the 3000mg and 4000mg per kg b.w. groups (that is in groups 6 and 7). This suggests that the extract may be cardio-protective giving that elevated plasma levels of VLDL is a potential risk for cardiovascular diseases. While the result showed ameliorative effect of the extract in reducing plasma VLDL levels, administration of lesser doses (100-, 200- and 400mg per kg body weight.) of the root extract of *Icacina senegalensis* decreased the plasma VLDL levels significantly ($p < 0.05$) in diabetic rats, as reported by Akuodor *et al* (2014), showing more efficacy.

Low Density Lipoprotein (LDL)

As shown in the above Graph, the palm oil-rich diet significantly elevated ($p < 0.05$) the negative control LDL level compared to the normal control, while the groups treated with the extract showed significantly reduced ($p < 0.05$) plasma LDL levels compared to the negative control. The result showed an approximate dose-dependent decrease and compares favourably with the effect of *Milletia aboensis* on plasma LDL, as reported by Onyegeme-okereanta and Essien (2015). LDL distributes cholesterol to peripheral tissues, however, elevated levels can lead to cardiovascular diseases. The ability of the extract to reduce the LDL levels may be due to the ability of certain component(s) of the extract to induce increased uptake by peripheral cells or hepatocytes, hence preventing certain cardiovascular diseases.

High-Density Lipoprotein (HDL)

The result showed a slight decrease in plasma HDL cholesterol, though not significant ($p > 0.05$), in the negative control compared to the normal control. The treated groups showed a slight increase in their plasma HDL levels, although not significant at $p < 0.05$. HDL cholesterol, termed “good cholesterol”, removes circulating plasma cholesterol, thus preventing possible oxidation that could lead to atherosclerosis, a potential risk to CVDs. Hence, by elevating plasma HDL levels, the extract may be cardioprotective. However, compared to the effects of *Milletia aboensis* and *Carica papaya* leaf extracts, which both resulted in a signi-

ficant increase ($p < 0.05$) in plasma HDL level, as reported by Onyegeme-okerinta and Essien (2015) and Gbolade *et al* (2010) respectively; *S. alata* (L) Roxb leaf extract may have a less-effective ability to protect against heart diseases.

Triglyceride (TG)

The result showed that triglyceride level was increased (but not significantly at $p < 0.05$) in the negative control compared to the normal control, while the treated groups showed an approximate dose-dependent decrease, which was only significant in the group treated with 4000mg per kg b.w. of the extract (group 7). The decrease in TG levels may be due to the rapid breakdown of fatty acids for energy production, since the result from Graph 3.1 showed a decrease in weight gain in the treated groups, implying that TG reduction in the plasma perhaps was not due to uptake by fatty cells, which would have led to weight gain. The leaf extract of *Milletia aboensis* at lower doses of 500mg, 1000mg, 1500mg, 2000mg and 2500mg per kg b.w. significantly reduced ($p < 0.05$) the plasma TG levels, as reported by Onyegeme-okerinta and Essien (2015); compared to the leaf extract of *S. alata* (L) Roxb that significantly reduced ($p < 0.05$) the TG levels at 4000mg per kg b.w. (a much higher dose). This implies that *Milletia aboensis* leaf extract may be more effective in lowering plasma TG levels than *S. alata* (L) Roxb leaf extract.

Effect on Liver Enzymes

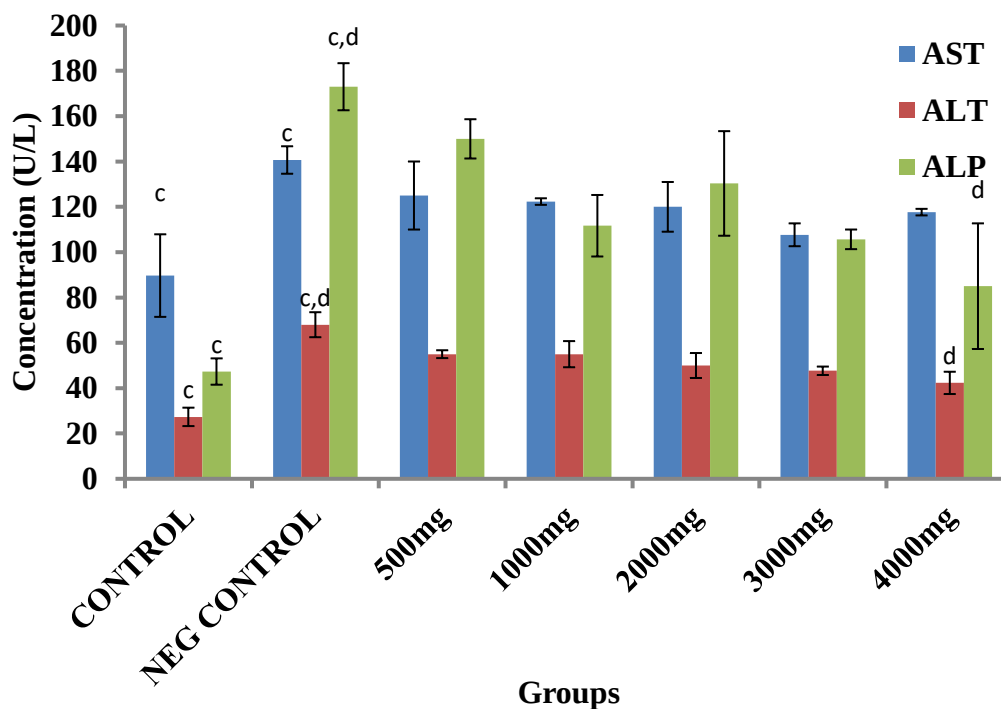


Figure 3: Effect of the aqueous leaf extract of *Senna alata* (L) Roxb on the liver enzymes of Wistar rats.

Bars represent values presented as mean $\pm$ SEM (n=3). Bars bearing the same alphabet with the negative control (untreated rats) differ significantly ($p < 0.05$) compared to the negative control. Bars without alphabets are not significantly ($p > 0.05$) different from the negative control.

Aspartate Transaminase (AST)

The result showed that AST level increased significantly ($p < 0.05$) in the negative control compared to the normal control group. That is, the palm oil-rich diet raised the plasma AST level significantly at $p < 0.05$. It also showed the capability of the extract in reducing the AST levels in the treated groups, in an almost dose-dependent pattern, with the 3000mg group being the most reduced. However, the AST levels in all the groups were above the normal reference range (6-40IU/L), although this cannot be linked to the effect of the extract, as the result shows that it rather reduced it. The elevated AST levels may imply an acute liver damage in the animals concerned, although not precisely, as it may also be linked to other sources such as leakage from the heart, skeletal muscles, kidney cells and erythrocytes. Other tests will be needed to ascertain the exact cause of elevation.

Alanine Transaminase (ALT)

ALT, another enzyme used to check for hepatocellular injury, was elevated significantly ($p < 0.05$) in the negative control compared to the normal control. As shown in Graph 4.3., after treatment for 21 days, the plasma ALT levels in the treated groups were reduced; but only the group treated with 4000mg per body weight of the extract was significantly reduced at $p < 0.05$. The result showed that the plasma ALT level of the negative control exceeded the upper limit of the normal range (56U/L); while other groups' fall within the normal range (7-56 U/L). This suggests that the palm oil-rich diet, over the 21-day period, may have increased the ALT levels in the plasma of the negative control group; as well as in other groups fed with the palm oil-rich diet, before being treated with the extract. The elevated ALT level may be suggestive of congestive heart disease, non-alcoholic fatty liver disease, obesity, myopathy or bile duct

Alkaline Phosphatase (ALP)

ALP catalyses the dephosphorylation of many biomolecules. High levels of ALP are found in the hepatocytes, cells that line the bile ducts, and bone cells. The result showed that the ALP level in the negative control group was increased significantly at $p < 0.05$, compared to that of the normal control; implying that the palm oil-rich diet may have been responsible for the elevation. The result, however, showed a dose-dependent reduction in the treated groups; with a significant reduction ($p < 0.05$) only in the 4000mg group. Elevated plasma ALP level is associated with large bile obstruction, cholestasis, infiltrative liver disease, and bone disorder. The result, therefore, showed that the extract has an ameliorative effect on the disorder(s) most likely induced by the palm oil-rich diet.

Effect on Bilirubin

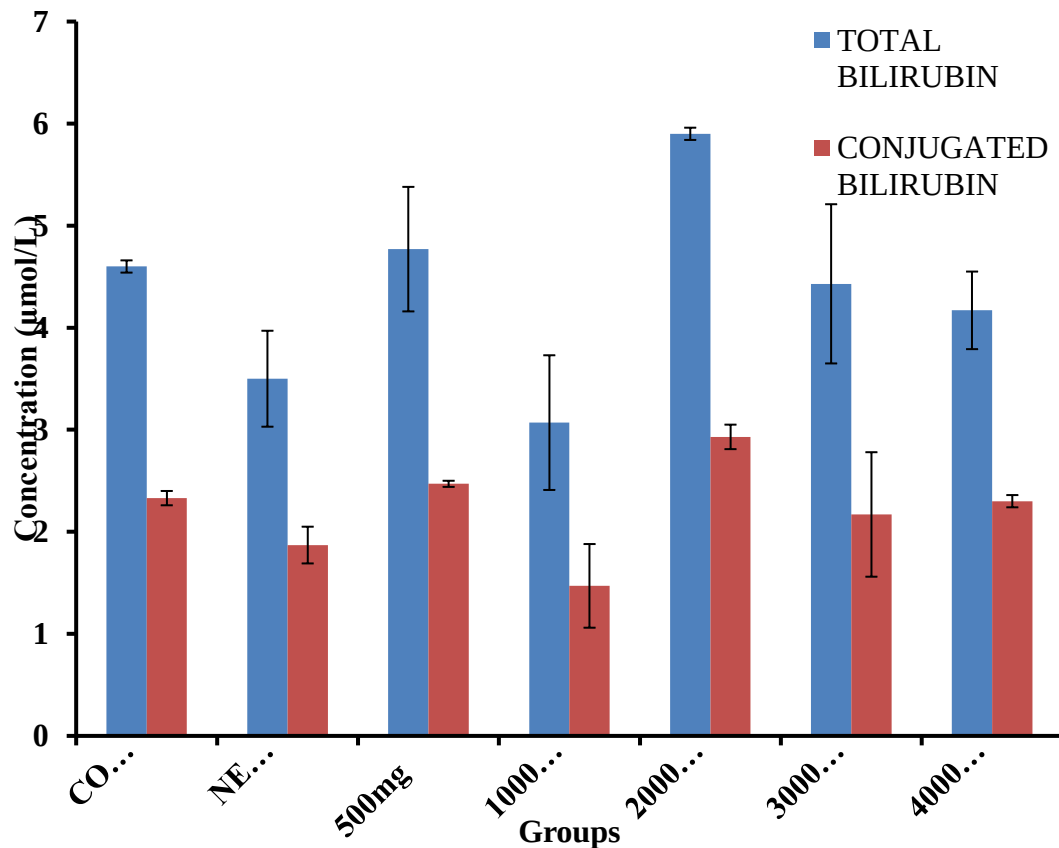


Figure 4: The effect of the aqueous leaf extract of *Senna alata* (L) Roxb on Bilirubin turnover in Wister rats.

Bars represent values presented as mean $\pm$ SEM (n=3). Bars bearing the same alphabet with the negative control (untreated rats) differ significantly ($p < 0.05$) compared to the negative control. Bars without alphabets are not significantly different from the negative control.

Total Bilirubin

Bilirubin is a by-product of the normal breakdown of the erythrocytes; particularly haemoglobin. Haem (“heme”), from haemoglobin, is converted to biliverdin and subsequently bilirubin. The bilirubin formed is poorly soluble, hence it is attached to albumin and delivered to the liver, from where it is conjugated to glucuronic acid by glucuronyl transferase to form soluble bilirubin diglucuronide (known as conjugated or direct bilirubin). Normal conjugation of bilirubin by the liver therefore correlates with normal liver function. The result in Graph 4.4 showed that the total bilirubin (blue bars) concentration was reduced

(not significantly at $p < 0.05$) in the negative control, compared to the normal control. The treated groups, however, showed an increase in their total plasma bilirubin levels (not significant at $p < 0.05$), compared to the negative control; apart from the 1000mg group (group 4) that was reduced (not significantly at $p < 0.05$) compared to the negative control group. The total bilirubin levels in all groups fall within the normal range (2.58 -25.84 $\mu\text{mol/L}$), showing normal erythrocytic lysis.

Conjugated Bilirubin

The level of conjugated bilirubin in the plasma of the negative control group shows a reduction (not significantly at $p < 0.05$) relative to the normal control. The treated groups showed a rise in their conjugated bilirubin levels, apart from the 1000mg group that showed a drop, compared to the negative control group. The level of conjugation in all groups, apart from the 2000mg group's, which was normal; fall below the normal range (2.58-10.34 $\mu\text{mol/L}$). The implication is that only the group treated with 2000mg per kg body weight of the extract may have normal liver function, while the other groups may have impaired liver function. The impairment may, however, not be connected to the extract, as the extract showed to improve on the liver functions in groups 500mg, 2000mg, 3000mg, and 4000mg; while the reason for the decrease in the 1000mg group could not be ascertained.

Histological Studies

The results of the effect of the aqueous leaf extract of *S. alata* (L) Roxb on the livers, hearts and kidneys of the Wister rats after 21days treatment are shown below.

The effect of the aqueous leaf extract of *S. alata* (L) Roxb on the livers of the Wister rats

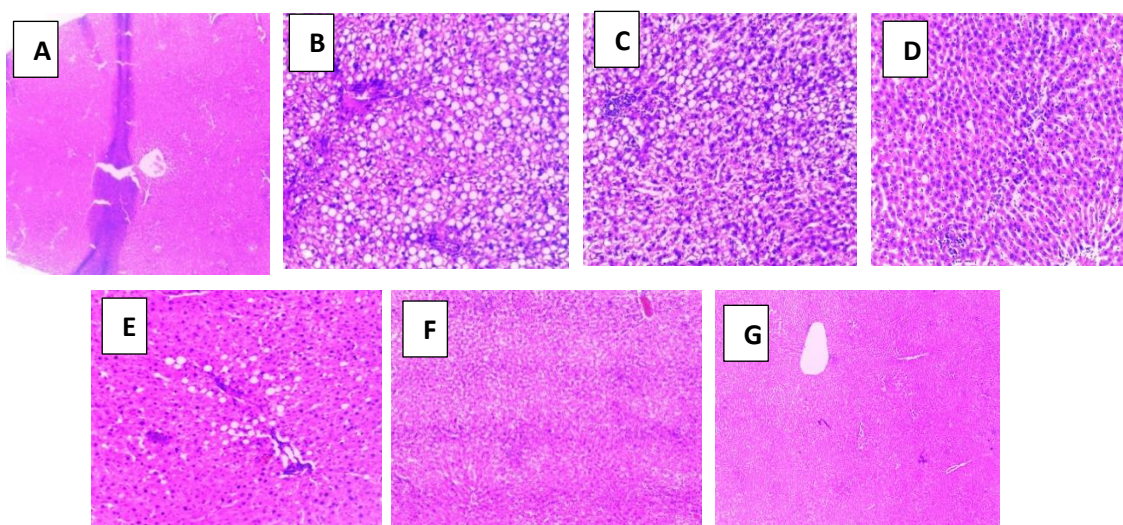


Plate I: Photomicrograph of the liver of rats. **A:** Control group showing normal liver architecture. **B:** Negative control group fed with palm oil-rich diet without

treatment showing severe fatty change with inflammation of hepatocytes. **C:** Group treated with 500mg/kg body weight of the aqueous leaf extract of *S. alata* (L) Roxb showing a fatty change in hepatocytes and portal /parenchymal inflammation. **D:** Group treated with 1000mg/kg body weight of the aqueous leaf extract of *S. alata* (L) Roxb mild fatty change and parenchymal inflammation. **E:** Group treated with 2000mg/kg body weight of the aqueous leaf extract of *S. alata* (L) Roxb showing inflammatory cells and mild fatty change. **F:** Group treated 3000mg/kg body weight of the aqueous leaf extract of *S. alata* (L) Roxb showing histologic slide showing mild vacuolar degeneration. **G:** Group treated 4000 mg/kg body weight of the aqueous leaf extract of *S. alata* (L) Roxb showing histologic slide showing no histologic change.

The effect of the aqueous leaf extract of *Senna alata* (L) Roxb on the Hearts of the Wister rats

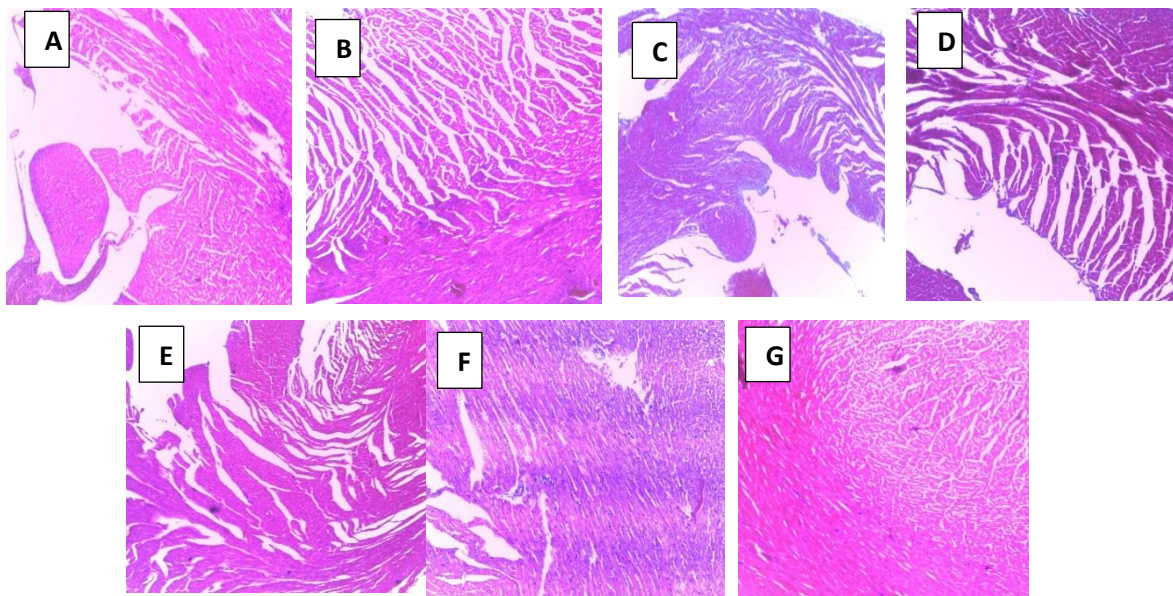


Plate II: Photomicrograph of the heart of rats. **A:** Control group showing normal histologic features. **B:** Negative control group fed with palm oil-rich diet without treatment showing congested vessels. **C-G:** Groups respectively treated with 500, 1000, 3000 and 4000mg/kg body weight with aqueous leaf extract of *S. alata* (L) Roxb showing no obvious histologic change.

The Effect of the Aqueous Leaf Extract of *Senna alata* (L) Roxb on the Kidneys of the Wister Rats

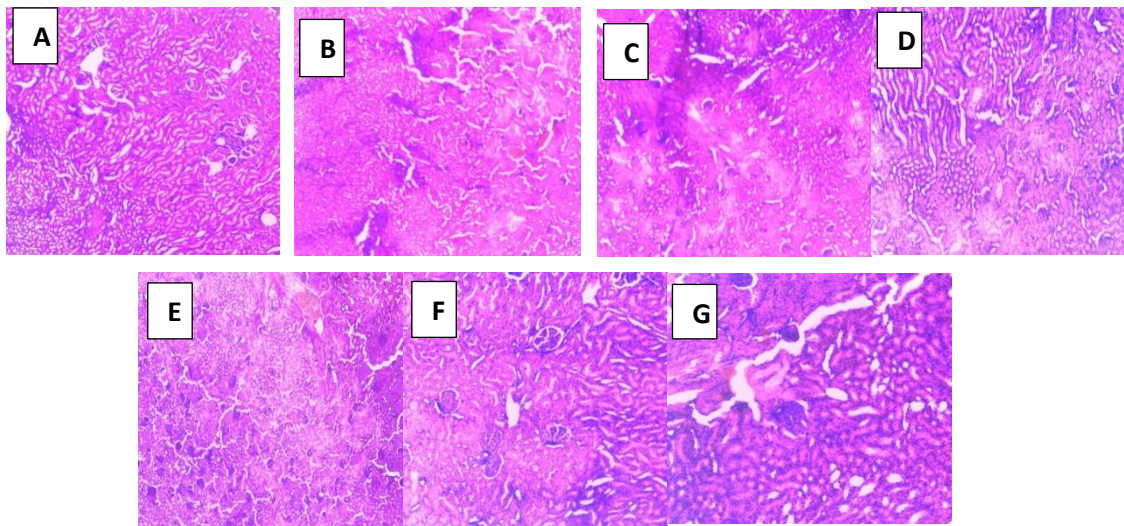


Plate III: Photomicrograph of the kidney of rats. **A:** Control group showing normal kidney architecture. **B:** Negative control group fed with palm oil-rich diet without treatment showing no obvious histologic change. **C-G:** Groups respectively treated with 500, 1000, 3000 and 4000mg/kg body weight of aqueous leaf extract of *S. alata* (L) Roxb showing no obvious histologic change.

The photomicrographs of the livers showed no histological change in the normal control, while there was a severe fatty change and inflammation in the liver of the negative control. Although still marked in the 500mg group, the fatty change and inflammation (as seen in the portal/parenchymal cells) began to recede as the extract dose increased from 500mg per kg body weight to 3000mg/kg body; and then showed no histological change in the 4000mg group. The interstitial oedema and vacuolar degeneration observed in the 3000mg group may be due to the long-term effect of the accumulated fatty droplets. The result showed that the extract may have some anti-inflammatory properties as well as ameliorate the adverse effect posed by fatty liver.

The photomicrographs of the hearts showed congestion in the coronary arteries of the heart, in the negative control group. This probably resulted from the elevation of LDL cholesterol, caused by the palm oil-rich diet, which may have been oxidised in the coronary arteries forming plaque. The hearts of the other groups (normal control, 500mg, 1000mg, 2000mg, 3000mg, and 4000mg) showed no histological change, implying that the extract may have had no deleterious effect to the hearts.

The kidneys of all the groups showed no histological change; this suggests that the extract may not have any negative effect on the kidneys, even at 4000mg/kg body weight.

Conclusion

This study reveals that palm oil, with high saturated fatty acid composition, may induce elevated plasma lipid, when taken in excess. The biochemical studies revealed that while continuous intake of palm-oil rich diet may impact negatively on the liver, probably causing bile duct obstruction; the leaves of *S. alata (L) Roxb* showed ameliorative effect. It further showed that *S. alata (L) Roxb* leaf may be used in the management of hyperlipidaemia, as well as its prevention, thus reducing the risk of atherosclerosis and consequently cardiovascular diseases; without causing any obvious damage to major organs like the heart, kidney, and liver. It may also be used in treating certain inflammatory diseases, as revealed by the histological findings.

Funding. This work was sponsored by the authors. The research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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Received: March 3, 2017; Published: April 8, 2017