



## **Effect of Methanolic Extract of *Corchorus olitorius* Leaves on Hypoglycemic and Hypolipidaemic Activities in Albino Rats**

**Augustine I. Airaodion<sup>1,2\*</sup>, Joanne D. Akinmolayan<sup>2</sup>, Emmanuel O. Ogbuagu<sup>3</sup>,  
Edith O. Airaodion<sup>4</sup>, Uloaku Ogbuagu<sup>1</sup> and Olaide O. Awosanya<sup>2</sup>**

<sup>1</sup>Department of Biochemistry, Federal University of Technology, Owerri, Imo State, Nigeria.

<sup>2</sup>Department of Pre-medical Science, Educational Advancement Centre, Ibadan, Oyo State, Nigeria.

<sup>3</sup>Department of Pharmacology and Therapeutics, Abia State University, Uturu, Nigeria.

<sup>4</sup>Department of Biochemistry, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author AIA designed the study and wrote the manuscript. Author JDA performed the statistical analysis. Author EOO managed the analyses of the study. Authors EOA and UO managed the literature searches while author OOA wrote the protocol of the study. All authors read and approved the final manuscript.*

### **Article Information**

DOI: 10.9734/APRJ/2019/v2i430054

#### Editor(s):

(1) Dr. Shri Kant Tripathi, Professor, Department of Forestry, Mizoram University, Aizawl, India.

(2) Dr. Vassya Bankova, Professor, Institute of Organic Chemistry with Centre of Phytochemistry, Bulgarian Academy of Sciences, Bulgaria.

#### Reviewers:

(1) Arthur N. Chuemere, University of Port Harcourt, Nigeria.

(2) S. Murugesan, University of Madras, India.

Complete Peer review History: <http://www.sdiarticle3.com/review-history/49731>

**Original Research Article**

**Received 15 April 2019**

**Accepted 25 June 2019**

**Published 02 July 2019**

### **ABSTRACT**

**Aim:** This study sought to investigate the hypoglycemic and hypolipidaemic effect of methanolic extract of *Corchorus olitorius* leaves in Albino rats.

**Methods:** Fresh plants of *C. olitorius* were harvested from the Institute of Agricultural Research and Training, Ibadan. The leaves were dried and extracted using soxhlet apparatus and methanol as the solvent. The methanol was evaporated in a rotary evaporator at 35°C with a yield of 2.17 g which represents a percentage yield of 8.68%. Ten adult male albino rats with body weight between 100 and 120 g were used for this study. They were randomly divided into two groups of five rats each. Animals in group 1 were administered saline solution while those in group 2 were

\*Corresponding author: E-mail: [augustineairadion@yahoo.com](mailto:augustineairadion@yahoo.com);

administered *C. olitorius* extract. The animals were exposed to the extract and saline solution at a dose of 3 mL per 100 g body weight 12 hourly via oral route of administration. After fourteen days of administration, the animals were fasted overnight and anaesthetized using diethyl ether. Blood samples were collected by cardiac puncture. Fasting blood sugar and lipid profile were determined using standard methods.

**Results:** *C. olitorius* leaves was observed to significantly lower fasting blood sugar, total cholesterol, LDL-cholesterol and triglyceride but increased HDL-cholesterol and HDL/LDL-cholesterol ratio significantly when compared to those of the control group at  $p < 0.05$ .

**Conclusion:** The result of this study implies that *C. olitorius* leaves are of significant health importance as far as hyperglucosemia and hyperlipidaemia is concerned. It could also be exceedingly helpful in the control of obesity and hypertension. This pharmacological study is a useful tool for further drug development from the natural plant products.

**Keywords:** *Corchorus olitorius* leaves; fasting blood sugar; lipid profile; diabetes; atherosclerosis.

## 1. INTRODUCTION

Lipids may be broadly defined as hydrophobic or amphiphilic small molecules; the amphiphilic nature of some lipids allows them to form structures such as vesicles, liposomes, or membranes in an aqueous environment [1]. Lipids are a large and diverse group of naturally occurring organic compounds that are related by their solubility in nonpolar organic solvents (e.g. ether, chloroform, acetone & benzene) and general insolubility in water [2]. They constitute a group of naturally occurring molecules that include fats, waxes, sterols, fat-soluble vitamins (such as vitamins A, D, E, and K), monoglycerides, diglycerides, triglycerides, phospholipids, etc. [3]. Although the term lipid is sometimes used as a synonym for fats, fats are a subgroup of lipids called triglycerides [4]. Lipids also encompass molecules such as fatty acids and their derivatives (including tri-, di-, monoglycerides, and phospholipids), as well as other sterol-containing metabolites such as cholesterol [5]. Although humans and other mammals use various biosynthetic pathways to synthesize and break down lipids, some essential lipids cannot be made this way and must be obtained from the diet [6]. Lipids have been reported to have several roles in the body [7].

*Corchorus olitorius* (Malvaceae) is a plant native to both tropical and subtropical regions throughout the world with mallow leaves commonly consumed as a leafy vegetable. The leaves have been reportedly used in ethnomedical practices to treat ache and pain, dysentery, malaria, enteritis, fever, gonorrhea, pectoral pains and tumors [8]. *C. olitorius* is a green leafy vegetable popularly consumed among the Yorubas of Southwestern Nigeria

where it is commonly called Ewedu. Among the Igbos of Southeastern, Nigeria, it is called Ahihara, while in English, the plant is known as jute mallow or bush okra. *C. olitorius* plant is not found in Nigeria only but also in other countries such as Egypt, Sudan, Malaysia, South America, and the Caribbean [9,10,11]. Nutritional substances; including calcium, potassium, phosphate, iron, ascorbic acid, carotene and large amount of mucilaginous polysaccharides have all been identified in the plant [12]. The phytochemical composition and its toxicity have also been investigated [13]. Medicinally, *C. olitorius* are used as a demulcent, diuretic, purgative, bitter tonic, laxative, refrigerant, carminative and lactagogue [14]. The leaves extract has given positive results in the management of chronic cystitis and dysuria [13]. Its reported high antibacterial activity gives credence to its use traditionally for the treatment of dysentery, fever and gonorrhea [12,14]. This study is therefore aimed at investigating its effect on blood glucose and lipid profile using albino rats.

## 2. MATERIALS AND METHODS

### 2.1 Collection and Extraction of Plant Material

Fresh plants of *C. olitorius* were harvested from the Institute of Agricultural Research and Training, Moor Plantation, Ibadan and were identified by a botanist. The leaves were carefully removed from the stem and washed in running water to remove contaminants. They were air dried at room temperature in an open laboratory space for 14 days and milled into powder using an electronic blender (Moulinex). The extraction was done using soxhlet apparatus and methanol as the solvent. About 25 g of the powder was

packed into the thimble of the soxhlet extractor. 250 ml of methanol was added to a round bottom flask, which was attached to the soxhlet extractor and condenser on a heating mantle. The solvent was heated using the heating mantle and began to evaporate moving through the apparatus to the condenser. The condensate dripped into the reservoir housing the thimble containing the sample. Once the level of the solvent reached the siphon, it poured back into the round bottom flask and the cycle began again. The process was allowed to run for a total of 18 hours. Once the process was completed, the methanol was evaporated in a rotary evaporator at 35°C with a yield of 2.17 g which represents a percentage yield of 8.68%. The extract was preserved in the refrigerator until when needed.

## 2.2 Animal Treatment

Ten adult male Albino rats (*Rattus norvegicus*) with body weight between 100 and 120 g were purchased from the Animal Holding Unit of the Department of Physiology, University of Ibadan, Nigeria. They were housed in Imrat animal house, Ibadan. They were acclimatized for seven (7) days during which they were fed *ad libitum* with standard feed and drinking water and were housed in clean cages placed in well-ventilated housing conditions (under humid tropical conditions) throughout the experiment. All the animals received humane care according to the criteria outlined in the 'Guide for the Care and Use of Laboratory Animals' prepared by the National Academy of Science and published by the National Institute of Health. They were randomly divided into two groups of five rats each. Animals in group 1 were administered normal saline solution while those in group 2 were administered *C. olitorius* extract. The animals were exposed to the extract and saline solution at a dose of 3 ml per 100 g body weight 12 hourly via oral route of administration. After fourteen days of administration, the animals were fasted overnight and anaesthetized using diethyl ether. Blood samples were collected by cardiac puncture.

## 2.3 Determination of Fasting Blood Sugar

After the acclimatization period, animals used in this study were allowed to fast for twelve (12) hours before the administration of saline solution and *C. olitorius* extract to groups 1 and 2 respectively. The blood glucose level were taken by sterilizing the tails of the animals with 10% alcohol, and cutting the tails using scissors then

allowing the blood to touch the test strip which was inserted into a calibrated glucose meter (One touch Glucometer, Acon Laboratory INC. San Diego, USA). This gave a direct reading after 5 seconds in mg/dL. The blood glucose level of the rats before the administration of locust bean was measured in order to know the normal blood glucose of the rats in each group. After the administration of *C. olitorius* leaves on the last day, all the rats in the groups were fasted again for 12 hours and their fasting blood sugar was determined using glucose meter. This was done in order to check and observe the effect of *C. olitorius* leaves on blood glucose level when compared to their initial glucose level (before the administration).

## 2.4 Determination of Lipids

Lipids were extracted and determined according to previously described methods [15,16].

## 2.5 Statistical Analysis

Data were subjected to analysis of variance using Graph Pad Prism. Results were presented as Mean  $\pm$  Standard Error of the Mean (SEM). 2-tailed t-test was used for comparison of the means. Differences between means were considered to be significant at  $p < 0.05$ .

## 3. RESULTS

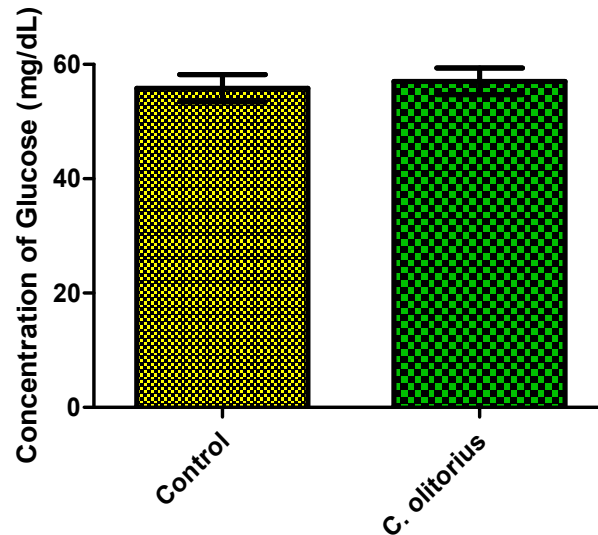
One major finding of this study was that *C. olitorius* leaves indeed unhinged and perturbed the concentrations of fasting blood sugar and lipids in the animals used. These perturbations were reflected as up/down regulation of the concentrations of these metabolites as shown in Figs. 1-8.

## 4. DISCUSSION

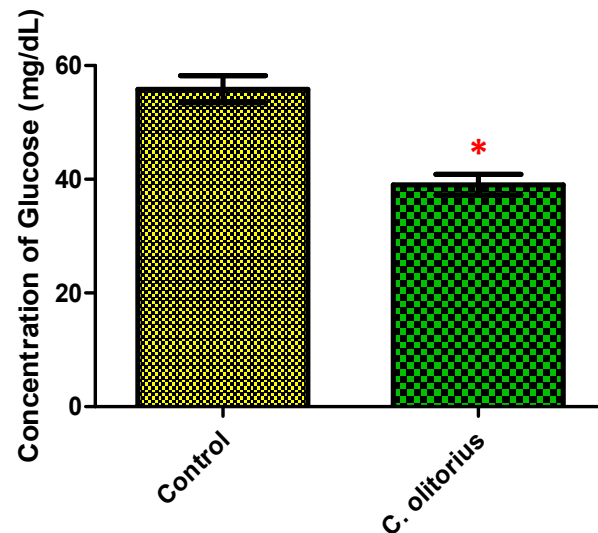
Diabetes is a complex metabolic disorder associated with developing insulin resistance, impaired insulin signaling and  $\beta$ -cell dysfunction, abnormal glucose and lipid metabolism, sub-clinical inflammation and increased oxidative stress. These metabolic disorders lead to long-term pathogenic conditions including micro- and macro-vascular complications, neuropathy, retinopathy, nephropathy, and a consequent decrease in quality of life and an increase in the rate of mortality [17]. Among the multiple risk factors underlining the incidence and progression of diabetes, diet is the main modifiable factor. Both experimental and epidemiological

evidences have shown that consumption of vegetables rich in phenolic compounds and possess high antioxidant capacity may have inverse relationship with the incidence and prevalence of diabetes [18]. Dietary control remains one of the most desirable avenues for the prevention and management of chronic degenerative diseases such as diabetes and cardiovascular diseases. The growing number of diabetics coupled with the harsh side effects of some synthetic drugs has led to the increasing search for alternatives which are relatively cheap

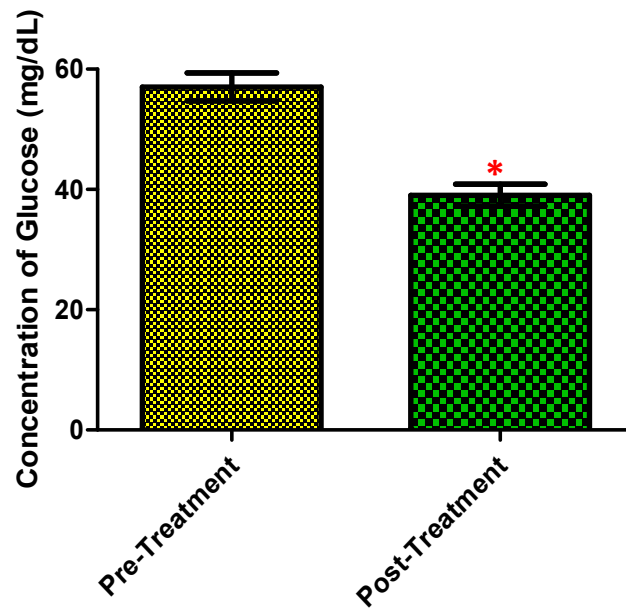
with minimal side effects. Green leafy vegetables and fruits have been reported to have some health benefits [19,20]. Consequently, *C. olitorius* leaf is a green leafy vegetable popularly used as food and in traditional medicine for the management of some diseases. However, there is dearth of information on the possible mechanisms of action by which these vegetables exert their health benefits. Therefore, this study sought to investigate the possible mechanisms of action of this vegetable in blood glucose and lipid profile, and its associated diabetic complications.



**Fig. 1. Fasting blood sugar of animals before treatment**  
Results are presented as mean $\pm$ SEM with  $n = 5$

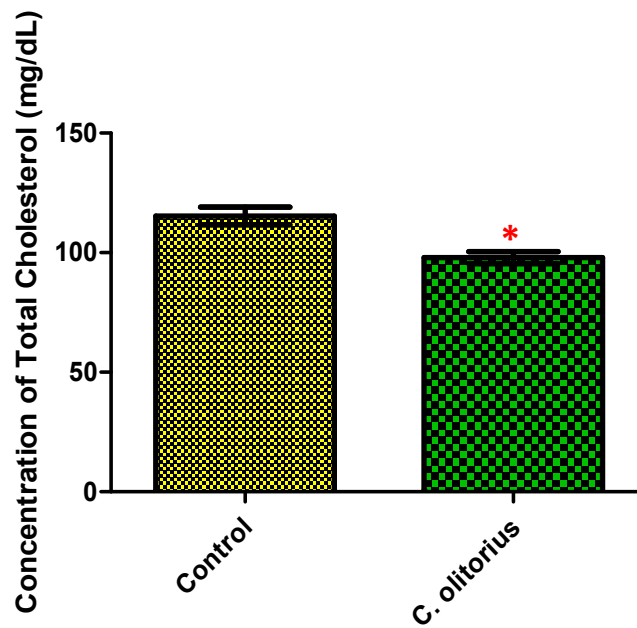


**Fig. 2. Fasting blood sugar after 14 days treatment**  
Results are presented as mean  $\pm$  SEM with  $n = 5$ . The significant difference between the *C. olitorius* leaves extract-treated animals and control group at  $p < 0.05$  is represented by \*



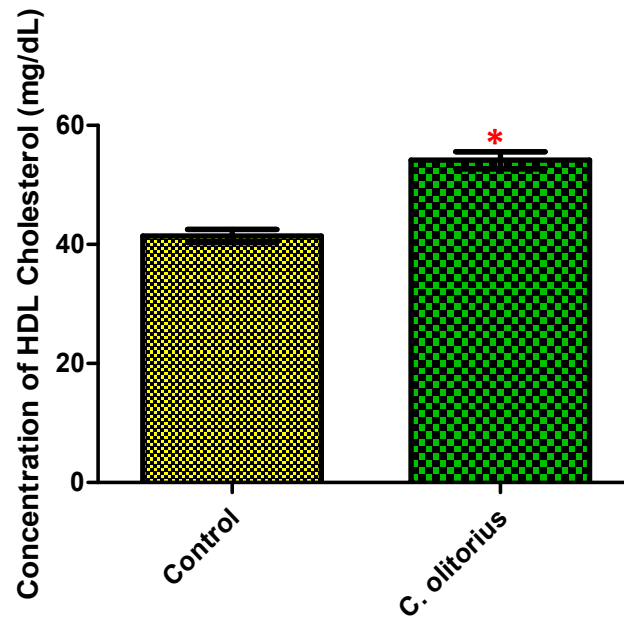
**Fig. 3. Effect of *C. olitorius* leaves extract administration on the fasting blood sugar of animals after 14 days**

Results are presented as mean  $\pm$  SEM with  $n = 5$ . The significant difference between the *C. olitorius* leaves extract-treated animals and control group at  $p < 0.05$  is represented by \*



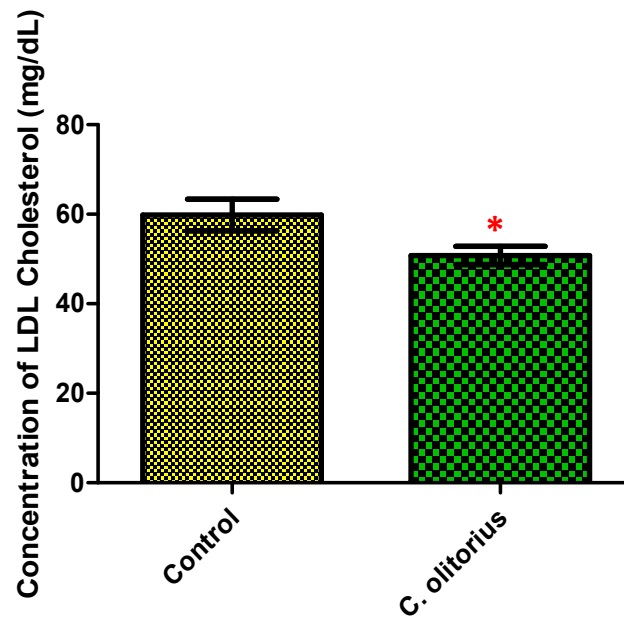
**Fig. 4. Effect of *C. olitorius* leaves extract administration on the total cholesterol of animals after 14 days**

Results are presented as mean  $\pm$  SEM with  $n = 5$ . The significant difference between the *C. olitorius* leaves extract-treated animals and control group at  $p < 0.05$  is represented by \*



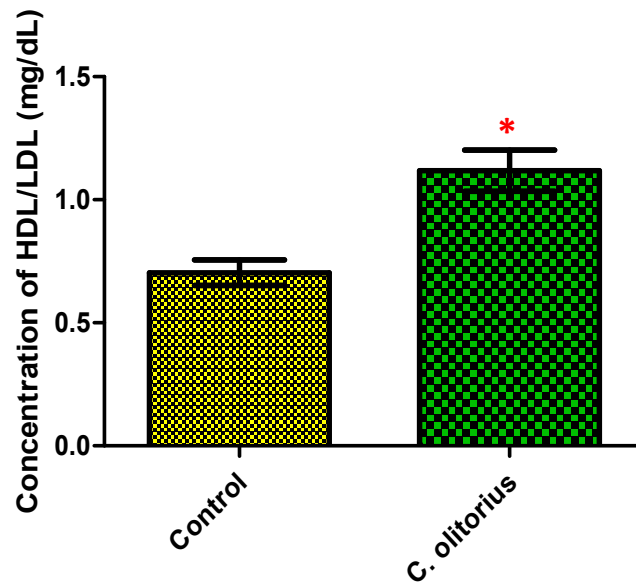
**Fig. 5. Effect of *C. olitorius* leaves extract administration on the HDL-cholesterol of animals after 14 days**

Results are presented as mean  $\pm$  SEM with  $n = 5$ . The significant difference between the *C. olitorius* leaves extract-treated animals and control group at  $p < 0.05$  is represented by \*



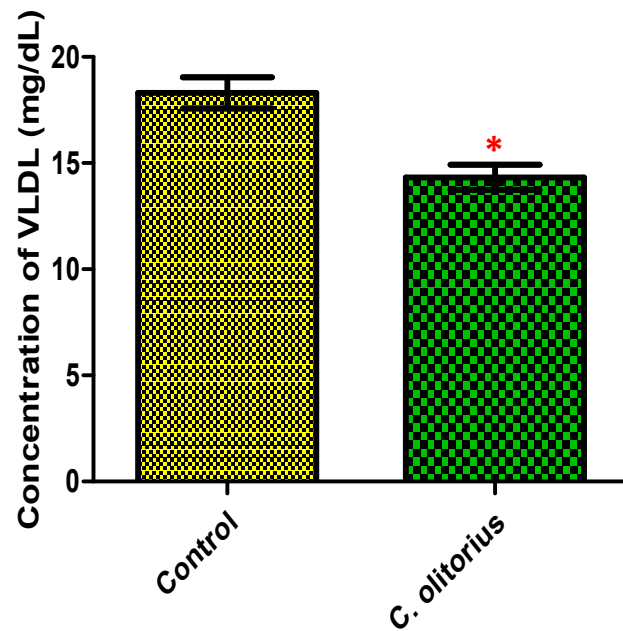
**Fig. 6. Effect of *C. olitorius* leaves extract administration on the LDL-cholesterol of animals after 14 days**

Results are presented as mean  $\pm$  SEM with  $n = 5$ . The significant difference between the *C. olitorius* leaves extract-treated animals and control group at  $p < 0.05$  is represented by \*



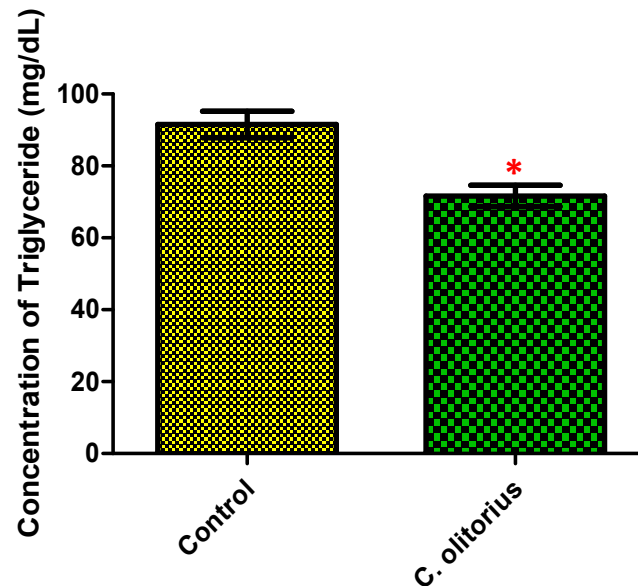
**Fig. 7. Effect of *C. olitorius* leaves extract administration on the HDL/LDL-cholesterol ratio of animals after 14 days**

Results are presented as mean  $\pm$  SEM with  $n = 5$ . The significant difference between the *C. olitorius* leaves extract-treated animals and control group at  $p < 0.05$  is represented by \*



**Fig. 8. Effect of *C. olitorius* leaves extract administration on the VLDL-cholesterol of animals after 14 days**

Results are presented as mean  $\pm$  SEM with  $n = 5$ . The significant difference between the *C. olitorius* leaves extract-treated animals and control group at  $p < 0.05$  is represented by \*



**Fig. 9. Effect of *C. olitorius* leaves extract administration on the Triglyceride of animals after 14 days**

Results are presented as mean  $\pm$  SEM with  $n = 5$ . The significant difference between the *C. olitorius* leaves extract-treated animals and control group at  $p < 0.05$  is represented by \*

In this study, no significant difference was observed in the fasting blood sugar when animals in the *C. olitorius* leaves group were compared with those of the control group prior to treatment (Fig. 1). After fourteen days of treatment, animals treated with *C. olitorius* leaves had significantly lowered fasting blood sugar when compared with control and pretreated groups (Figs. 2 and 3) respectively. This suggests that *C. olitorius* leaves may have an extrapancreatic antihyperglycemic mechanism of action. This is in agreement with the study of Airaodion et al. [21] on the effect of oral intake of African locust bean on fasting blood sugar and lipid profile of albino rats. A number of other plants and extracts have also been reported to have an antihyperglycemic and an insulin-stimulatory effect. [22,23,24]. Most of the plants with hypoglycemic properties have been found to contain metabolites such as glycosides, alkaloid and flavonoids [19,20,25].

Chemical investigation of *C. olitorius* leaves has shown that they contain flavonoids, alkaloids, glycoside, and phenolic compounds [13]. These chemical substances may then be responsible for the hypoglycemic effect of *C. olitorius* leaves observed in this study. The fasting blood sugar lowering effect of *C. olitorius* leaves may also indicate that it possesses antidiabetic agents

which could control hyperglycemia. This is in consonance with earlier reports that green leafy vegetables possess antidiabetic properties [26,27]. One therapeutic approach for treating early stage of diabetes is to decrease post-prandial hyperglycaemia. This is done by retarding the absorption of glucose through the inhibition of the carbohydrate-hydrolyzing enzymes,  $\alpha$ -amylase and  $\alpha$ -glucosidase, in the digestive tract. Consequently, inhibitors of these enzymes determine a reduction in the rate of glucose absorption and consequently blunting the post-prandial plasma glucose rise [28]. Based on these findings, it could be suggested that *C. olitorius* leaves may inhibit platelet aggregation and promote vasodilatation, exerting an important protective role in the prevention of the development and progression of vascular complications caused by the hyperglycemic state. In fact, studies have shown that polyphenolic compounds present in some plant foods can inhibit the process of thrombus formation [29,30].

Apart from the regulation of carbohydrate metabolism, insulin plays an important role in lipid metabolism. Insulin insufficiency, as in diabetes mellitus, is associated with hypercholesterolemia and hypertriglyceridemia, which have been reported to occur in



experimental diabetic rats [31,32,33]. Hypercholesterolemia could result in a relative molecular ordering of the residual phospholipids, resulting in a decrease in membrane fluidity [34]. Accumulation of triglycerides is one of the leading risk factors in coronary heart disease (CHD). Lipid and lipoprotein abnormalities have been shown to play a major role in the pathogenesis and progression of several disease conditions [35].

In this study, total cholesterol and triglycerides concentrations were observed to decrease significantly when animals treated with *C. olitorius* leaves were compared with those of the control group at  $p < 0.05$  (Figs. 4 and 9 respectively). This could be that *C. olitorius* leaves may prevent the progression of CHD. Despite the availability of known anti-diabetic medications, remedies from medicinal plants are used with increasing success to treat this disease and manage its complications better [36]. Furthermore, it has been suggested that plant drugs and herbal formulations are less toxic and are free from side-effects compared with synthetic drugs, leading to an increasing preference for traditional plants over synthetic drugs [37-41]. Increased evidence of therapeutic effectiveness of herbal medicines may have influenced the interest of world health organization (WHO) in hypoglycemic agents of plant origin used in the traditional treatment of diabetes [42]. Hypertriglyceridaemia has been reported in diabetic animals [43]. This was reported to be due to an increased absorption and formation of triglycerides in the form of chylomicrons following exogenous consumption of diet rich in fat or through increased endogenous production of triglyceride-enriched hepatic VLDL-cholesterol and decreased triglyceride uptake in peripheral tissues [43]. Hypercholesterolaemia has also been reported in diabetic animals [43]. This was attributed to the increased dietary cholesterol absorption from the small intestine following the intake of high fat diet in a diabetic condition [44]. However, the levels of serum triglyceride, VLDL-cholesterol and total cholesterol were significantly reduced in animals treated with extracts of *C. olitorius* leaves when compared with those of the control group in the present study. Moreover, it can be conjectured that the lipid lowering effects of *C. olitorius* leaves could be due to the inhibition of hepatic cholesterol, triglyceride and possibly fatty acid synthesis by the phenolic constituents of *C. olitorius* leaves [27].

Hypertriglyceridaemia has also been reported to be a predictor of hypertension risk [45]. In the peripheral vascular system, endothelial cells rely on lipoproteins for the transfer of neutral sterols at this site. Although free cholesterol is transferred to HDL-cholesterol particles through the functioning of a designated HDL-cholesterol receptor, lecithin cholesterol acyl transferase (LCAT) serves to maintain the concentration toward the HDL core and preserve the hydrophobic nature that facilitates the transfer. Esterification of cholesterol produces cholesterol ester (CE), which is concentrated in HDL core, and may be transferred by cholesterol ester transfer protein (CETP) in the plasma compartment to apo-B containing lipoproteins in exchange for triglyceride. Increased CETP activity would suggest an enrichment of apo-B lipoproteins in plasma, while simultaneously decreasing HDL-cholesterol, and has generally been considered pro-atherogenic [46]. This probably explains why *C. olitorius* leaves may lead to a reduction in the risk of developing heart diseases since a high HDL-cholesterol/LDL-cholesterol ratio has been shown to be beneficial and is indicative of a lower risk of cardiovascular diseases [47].

HDL-cholesterol and LDL-cholesterol are two of the four main groups of plasma lipoproteins that are involved in lipid metabolism and the exchange of cholesterol, cholesterol ester and triglycerides between tissues [48,49]. Numerous population studies have shown an inverse correlation between plasma HDL-cholesterol levels and risk of cardiovascular disease, implying that factors associated with HDL-cholesterol protect against atherosclerosis. Some of these factors appear to have antioxidant and anti-inflammatory effects which may obviate processes that initiate atherogenesis [50,51].

Epidemiological studies have also shown that elevated concentrations of total cholesterol and/or LDL-cholesterol in the blood are powerful risk factors for coronary heart disease [52]. Most extra-hepatic tissues, although having a requirement for cholesterol, have low activity of the cholesterol biosynthetic pathway. Their cholesterol requirements are supplied by LDL, which is internalized by receptor-mediated endocytosis. A major function of HDL-cholesterol is to enhance reverse cholesterol transport by scavenging excess cholesterol from peripheral tissues followed by esterification through lecithin: cholesterolacyltransferase and delivering it to the liver and steroidogenic organs for subsequent

synthesis of bile acids and lipoproteins and eventual elimination from the body [53,54]. This role of HDL-cholesterol has been shown to be responsible for its atheroprotective properties. HDL-cholesterol also regulates the exchange of proteins and lipids between various lipoproteins.

In addition, HDL-cholesterol provides the protein components required to activate lipoprotein lipase which releases fatty acids that can be oxidized by the  $\beta$ -oxidation pathway to release energy [48,49]. Most importantly, HDL-cholesterol can inhibit oxidation of LDL-cholesterol as well as the atherogenic effects of oxidized LDL-cholesterol by virtue of its antioxidant property [54]. LDL is a lipoprotein that transports cholesterol and triglyceride from the liver to peripheral tissues. It enables fat and cholesterol to move within the water-blood solution of the blood stream. LDL is often called bad cholesterol; hence low levels are beneficial [55].

Interestingly, the administration of *C. olitorius* leaves in this study caused a significant increase in the serum level of HDL-cholesterol when compared with the control animals (Fig. 5) at  $p < 0.05$ . HDL-cholesterol is usually referred to as the 'good cholesterol' [15]. Again, *C. olitorius* leaves administration significantly decreased the concentration of LDL-cholesterol (bad cholesterol) when compared with that of the control group at  $p < 0.05$  (Fig. 6). This result contradicts the findings of Airaodion et al. [21] who reported a non-significant difference in the LDL-cholesterol concentration when animals were treated with African locust bean for 14 days. The combined effect of increased HDL-cholesterol (good cholesterol) and decreased LDL-cholesterol (bad cholesterol) in the present study resulted in an increased HDL-cholesterol/LDL-cholesterol ratio in animals treated with *C. olitorius* leaves when compared with the control group (Fig. 7). This strongly supports the notion that dietary supplementation with the extract of *C. olitorius* leaves may lead to a reduction in the risk of developing heart diseases, because a high HDL-cholesterol/LDL-cholesterol ratio has been shown to be beneficial and is indicative of a lower risk of CHD [56]. Although, the activities of enzymes were not investigated in this study, but it is possible that *C. olitorius* leaves decreased the activity of 3-hydroxy-3-methylglutaryl coenzyme A (HMG CoA) reductase (the rate-limiting enzyme in cholesterol biosynthesis) [16]. *C. olitorius* leaves

have also been reported to ameliorate the effect of ethanol-induced oxidative stress [57].

## 5. CONCLUSION

The result of this study implies that *C. olitorius* leaves are of significant health importance as far as hyperglucosemia and hyperlipidaemia is concerned. It could also be exceedingly helpful in the control of obesity and hypertension. This pharmacological study is a useful tool for further drug development from the natural plant products.

## ETHICAL APPROVAL

As per university standard guideline ethical approval has been collected and preserved by the authors.

## ACKNOWLEDGEMENT

Authors wish to appreciate Mr. Agbaje who took care of the animals throughout the period of this research.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

## REFERENCES

1. Subramaniam S, Fahy E, Gupta S, Sud M, Byrnes RW, Cotter D, Dinasarapu AR, Maurya MR. Chemical Reviews. 2011; 111(10):6452–6490.
2. Fahy E, Subramaniam S, Murphy R, Nishijima M, Raetz C, Shimizu T, Spener F, Van Meer G, Wakelam M, Dennis EA. Journal of Lipid Research. 2009;50 (Supplement):S9–S14.
3. Page RA, Okada S, Harwood JL. AcetylCoA carboxylase exerts strong flux control over lipid synthesis in plants. Biochim. Biophys. Acta. 1994;1210:369–372.
4. Small DM. The physical chemistry of lipids. Handbook of Lipid Research. D. J. Hanahan, Editor. Plenum Press, New York. 1986;4.
5. Michelle A, Hopkins J, McLaughlin CW, Johnson S, Warner MQ, LaHart D, Wright JD. Human biology and health. Englewood Cliffs, New Jersey, USA: Prentice Hall; 1993.

6. Airaodion AI, Adejumo PR, Njoku CO, Ogbuagu, EO, Ogbuagu U. Implication of sugar intake in haemorrhoid and menstruation. International Journal of Research and Reports in Hematology. 2019;2(2):1-9.
7. Airaodion AI, Ogbuagu U, Ogbuagu EO, Oloruntoba AP, Agunbiade AP, Airaodion EO, Mokelu IP, Ekeh SC. Mechanisms for controlling the synthesis of lipids. International Journal of Research. 2019; 6(2):123-135.
8. Adedosu OT, Akanni OE, Afolabi OK, Adedeji AL. Effects of *Corchorus olitorius* Extract on Certain Antioxidants and Biochemical Indices in Sodium Arsenite Exposed Rats. American Journal of Phytomedicine and Clinical Therapeutics. 2015;3(03):245-256.
9. Onyeka EU, Nwambekwe IO. Phytochemical profile of some green leafy vegetables in South East, Nigeria. Nigeria Institute of Food Science and Technology; 2007.
10. Ujah OF, Ipav SS, Ayaebene CS, Ujah C. Phytochemistry and hepatoprotective effect of ethanolic leaf extract of *Corchorus olitorius* on carbon tetrachloride induced toxicity. European Journal of Medicinal Plants. 2014;4(8):882-892.
11. Nemba RM, Emadak A, Mouzong GC, Nemba CE. Qualitative and quantitative assesment of mineral elements in the leaves of *Corchorus fascicularis* and *Corchorus olitorius* harvested in Cameroon. J Curr Chem Pharm Sci. 2012; 2(1):17-23.
12. Al Batran RA, Al Bayaty F, Abdulla MA, Al Obaidi MM, Hajrezae IM, Hassandarvish, P, Fouad M, Golbabapour S, Talaee S. Gastroprotective effect of *Corchorus olitorius* leaf extract against ethanol-induced gastric mucosal hemorrhagic lesion in rats. J. gastroenterol hepatol. 2013;28(8):1321-1329.
13. Orieko D, Ohaeri OC, Ijeh II, Ijioma SN. Identification of Phytocomponents and Acute Toxicity Evaluation of *Corchorus olitorius* Leaf Extract. European Journal of Medicinal Plants. 2018;23(1): 1-16.
14. Egua MO, Etuk EU, Bello SO, Hassan SW. Anti-diabetic activity of ethanolic seed extract of *Corchorus olitorius*. International Journal of Sciences: Basic and Applied Research. 2013;12(1):8-21.
15. Owoade AO, Adetutu A, Airaodion AI, Ogundipe OO. Toxicological assessment of the methanolic leaf extract of *Bridelia ferrugelia*. The Journal of Phytopharmacology. 2018;7(5):419-424.
16. Owoade AO, Airaodion AI, Adetutu A, Akinyomi OD. Levofloxacin-induced dyslipidemia in male albino rats. Asian Journal of Pharmacy and Pharmacology. 2018;4(5):620-629.
17. Santaguida PL, Balion C, Hunt D. Diagnosis, prognosis, and treatment of impaired glucose tolerance and impaired fasting glucose. Evid Rep Technol Assess. 2008;12:1–11.
18. Bahadoran Z, Golzarand M, Mirmiran P, Saadati N, Azizi F. The association of dietary phytochemical index and cardio-metabolic risk factors inadults: Tehran lipid and glucose study. Journal of Human Nutrition and Diet. In Print; 2013.
19. Airaodion AI, Olatoyinbo PO, Ogbuagu U, Ogbuagu EO, Akinmolayan JD, Adekale OA, Awosanya OO, Oloruntoba AP, Agunbiade AP, Airaodion EO, Adeniji AR, Obajimi OO. Comparative assessment of phytochemical content and antioxidant potential of *Azadirachta indica* and *Parquetina nigrescens* leaves. Asian Plant Research Journal. 2019;2(3): 1-14.
20. Airaodion AI, Ibrahim AH, Ogbuagu U, Ogbuagu EO, Awosanya OO, Akinmolayan JD, Njoku OC, Obajimi OO, Adeniji AR, Adekale OA. Evaluation of Phytochemical Content and Antioxidant Potential of *Ocimum gratissimum* and *Telfairia occidentalis* Leaves. Asian Journal of Research in Medical and Pharmaceutical Sciences. 2019;7(1):1-11.
21. Airaodion AI, Airaodion EO, Ogbuagu EO, Ogbuagu U, Osemwowa EU. Effect of Oral Intake of African Locust Bean on Fasting Blood Sugar and Lipid Profile of Albino Rats. Asian Journal of Research in Biochemistry. 2019;4(4):1-9.
22. Prince P, Stanely M, Menon PV, Pari L. Hypoglycaemic activity of *Syzygium cumini* seeds: Effect on lipid peroxidation in alloxan diabetic rats. J. Enthopharmacol. 1998;61:1–7.
23. Venkateswaran S, Pari L, Saravenan G. Effect of *Phaseolus vulgaris* on circulatory antioxidants and lipids in streptozotocininduced diabetic rats. J. Med. Food. 2002;5:97–104.
24. Latha M, Pari L. Preventive effects of *Cassia auriculata* L. flowers on brain lipid peroxidation in rats treated with

- streptozotocin. Mol. Cell. Biochem. 2003; 243:23–28.
25. Loew S, Kaszkin M. Approaching the problem of bioequivalence of herbal medicinal products. Phytother. Res. 2002; 16:705–711.
26. Zhang L, Yang J, Chen X, Zan K, Wen X, Chen H, Wang Q, Lai M. Antidiabetic and antioxidant effects of extracts from *Potentilla discolor* Bunge on diabetic rats induced by high fat diet and streptozotocin. Journal of Ethnopharmacology. 2010;132:518–524.
27. Balamurugan R, Ignacimuthu S. Antidiabetic and Hypolipidemic effect of methanol extract of *Lippia nodiflora* L. in streptozotocin induced diabetic rats. Asia Pacific Journal of Tropical Biomedicine. 2011;S30-S36.
28. Chen X, Zheng Y, Shen Y, Voglibose BAO. One of the most important  $\alpha$ - glucosidase inhibitors. Current. Medical. Chemistry. 2006;13: 109-116.
29. Dohadwala MM, Vita JA. Grapes and cardiovascular disease. Journal of Nutrition. 2009;139(9):1788–1793.
30. Gresele P, Cerletti C, Guglielmini G, Pignatelli P, de Gaetano G, Violi F. Effects of resveratrol and other wine polyphenols on vascular function: An update. Journal of Nutritional Biochemistry. 2011;22(3):201–211.
31. Loci AS, Shaabha M, Khazraji AL, Husain A, Twaija A. Hypoglycemic effect of a valuable extract on some blood parameters in diabetic animals. J. Ethnopharmacol. 1994;43:167–171.
32. Ahardh CD, Bjorgell P, Nilson EP. The effect of tolmetamide in lipoproteins and lipoprotein lipase and hormone sensitive lipase. Diabetes Res. Clin. Pract. 1999;46: 99–108.
33. Frayn KN. Insulin resistance and lipid metabolism. Curr. Opin. Lipidol. 1993;4: 197–204.
34. Bopanna KN, Kannan J, Suchma G, Balaraman R, Ranthod SP. Antidiabetic and antihyperlipidemic effect of neem seed, kernel powder on alloxan diabetic rabbits. Ind. J. Pharmacol. 1997;29:162–167.
35. Rotimi OS, David AO, Olusola AT, Regina NU, Elizabeth AB, Oladipo A. Amoxillin and pefloxacin-induced cholesterogenesis and phospholipidosis in rat tissues. Lipids in Health and Disease. 2015;14: 13-30.
36. Bhattaram VA, Cercefe M, Cohlest C, Vest M, Deundo FH. Pharmacokinetics bioavailability herbal medicinal products. Phytomedicine. 2002;9:1–36.
37. Airaodion AI, Ogbuagu U, Ogbuagu EO, Airaodion EO, Agunbiade AP, Oloruntoba AP, Mokelu IP, Ekeh SC. Investigation of aqueous extract of *Zingiber officinale* root potential in the prevention of peptic ulcer in albino rats. International Journal of Research and Innovation in Applied Science. 2019;4(2):64-67.
38. Airaodion AI, Obajimi OO, Ezebuio CN, Ogbuagu U, Agunbiade AP, Oloruntoba AP, Akinmolayan JD, Adeniji AR, Airaodion EO. Prophylactic efficacy of aqueous extract of *Curcuma longa* against indomethacin-induced ulcer. International Journal of Research. 2019;6(1):87-91.
39. Airaodion AI, Olayeri IM, Ewa AO, Ogbuagu EO, Ogbuagu U, Akinmolayan JD, Agunbiade AP, Oloruntoba AP, Airaodion EO, Adeniji AR, Obajimi OO, Awosanya OO. Evaluation of *Moringa oleifera* leaf potential in the prevention of peptic ulcer in albino rats. International Journal of Research. 2019;6(2):579-584.
40. Saravanan R, Pari L. Antihyperlipidemic and antiperoxidative effect of diasulin, a polyherbal formulation in alloxan induced hyperglycemic rats. BMC Complement. Alternative Med. 2005;5:14–34.
41. Airaodion AI, Adekale OA, Airaodion EO, Ogbuagu EO, Uloaku Ogbuagu U, Osemwowa EU. Efficacy of Combined crude Extract of *Curcuma longa* and *Moringa oleifera* in the Prevention of Peptic Ulcer in Albino Rats. Asian Journal of Research in Medical and Pharmaceutical Sciences. 2019;7(2):1-8.
42. Shoback DG, Gardner D, Eds. "Chapter 17". Greenspan's Basic & Clinical Endocrinology (9th Ed.). New York: McGraw-Hill Medical; 2011. ISBN: 978-0-07-162243-1.
43. Saliu JA, Oboh G, Schetinger MR, Stefanello N, Rocha JBT. Antidiabetic Potentials of Jute Leaf (*Corchorus olitorius*) On Type-2 Diabetic Rats. Journal of Emerging Trends in Engineering and Applied Sciences (JETEAS). 2015;6(7): 223- 230.
44. Srinivasan K, Viswanad B, Asrat L, Kaul CL, Ramarao P. Combination of high-fat diet-fed and low-dose streptozotocin-treated rat: A model for type 2 diabetes and pharmacological screening.

- Pharmacological Research. 2005;52:313–320.
45. Allen RR, Carson LA, Kwik-Urbe C, Evans E, Erdman JW. Daily consumption of a dark chocolate containing flavanols and added sterol esters affects cardiovascular risk factors in normotensive population with elevated cholesterol. *J Nutr.* 2008;138: 725-731.
46. Greene CM, Zern TL, Wood RJ, Shrestha S, Fernandez ML. Maintenance of the LDL-cholesterol/ HDL-cholesterol ratio in an elderly population given a dietary cholesterol challenge. *J Nutr.* 2005;135: 2793-2798.
47. Perona JS, Covas MI, Fito M, Cabello-Moruno R, Aros F, Corella D, Ros E, Garcia M, Estruch R, Martinez-Gonzalez MA, Ruiz-Gutierrez V. Reduction in systemic and VLDL triacylglycerol concentration after a 3-month Mediterraneanstyle diet in high-cardiovascular-risk subjects. *J Nutr Biochem.* 2010;9:892-898.
48. Gordon DJ, Rifkind BM. High-density lipoprotein: The clinical implications of recent studies. *New England Journal of Medicine.* 1989;321(19):1311-1316.
49. Sviridiv D. Intracellular cholesterol trafficking. *Histology and Histopathology.* 1999;14:305-319.
50. Navab M, Berliner JA, Watson AD, Hama SY, Territo MC, Lusis AJ, Shih DM, Van Lenten BJ, Frank JS, Demer LL, Edwards PA, Fogelman AM. The Yin and Yang of oxidation in the development of the fatty streak. A review based on the George Lyman Duff Memorial Lecture. *Arteriosclerosis and Thrombosis in Vascular Biology.* 1994;16:831-842.
51. Oram JF, Lawn RM. ABCA1: The gatekeeper for eliminating excess tissue cholesterol. *Journal Lipid Research.* 2001; 42:1173-1179.
52. Law MR. Lowering heart disease risk with cholesterol reduction: Evidence from observational studies and clinical trials. *European Heart Journal.* 1999;1:S3-S8.
53. Stein O, Stein Y. Atheroprotective mechanisms of HDL- Atherosclerosis. 1999;144:285-303.
54. Das DK. Cardioprotection with high density lipoproteins. Fact or friction? *Circulation Research.* 2003;92:258-260.
55. Cromwell WC, Otvos JD. Low Density Lipoprotein Particle Number and Risk for Cardiovascular Disease. *Curr. Atheroscler. Rep.* 2004;6(8):381-387.
56. Castelli L. Epidemiology of coronary heart disease. *Am. J. Med.* 1984;76:4–12.
57. Airaodion AI, Ogbuagu EO, Ewa O, Ogbuagu U, Awosanya OO, Adekale OA. Ameliorative efficacy of methanolic extract of *Corchorus olitorius* leaves against acute ethanol-induced oxidative stress in albino rats. *Asian Journal of Biochemistry, Genetics and Molecular Biology.* 2019; 9(6):1-8.

© 2019 Airaodion et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:  
The peer review history for this paper can be accessed here:  
<http://www.sdiarticle3.com/review-history/49731>