Original Research Article

Prophylactic Potential of *Corchorus olitorius*Leavesagainst Experimentally-$KBrO_3$-induced Dyslipidemia

ABSTRACT

Background: Our literature searches revealed that no studies have examined the ameliorative impact of *Corchorus olitorius* leaves on dyslipidaemia caused by potassium bromate ($KBrO_3$). Therefore, the purpose of this study was to determine whether *C. olitorius* leaves could prevent $KBrO_3$-induced dyslipidaemia.

Methodology: Fresh *Corchorus olitorius* (jute) plants were gathered from Institute of Agricultural Research and Training's Moor Plantation, Nigeria. Using a soxhlet system and ethanol as the solvent, they were extracted. For the experiment, 24 male Wistar rats were employed. They were allowed to be used to a lab environment for seven (7) days before the experiment. They were divided into groups A, B, C, and D at random. Group A received oral distilled water as the control group. In addition to the 100 mg/kg body weight of potassium bromate given to groups B, C, and D, animals in groups C and D also received 100 and 200 mg/kg body weight of *C. olitorius*, respectively. Oral gavage was used to administer *C. olitorius* extract and freshly made potassium bromate to rats every day for 28 days. Twenty-four hours after the last treatment, the animals were killed under gentle sedation with diethyl ether. Blood was drawn by puncturing the heart. Also taken from the animals was their heart.

Results: In comparison to the untreated group, the research animals given $KBrO_3$ had considerably higher plasma levels of total cholesterol, triglycerides, LDL, VLDL, and the CHD risk ratio, whereas their levels of HDL and the HDL/LDL ratio were much lower. When compared to the control group, treatment with $KBrO_3$ significantly decreased cardiac levels of total cholesterol, HDL, and HDL/LDL ratio, while increasing levels of triglycerides, LDL, and VLDL as well as the CHD risk ratio. *C. olitorius* reduced these abnormalities in a dose-dependent manner.

Conclusion:*Corchorus olitorius* leaves were found to have hypolipidaemic effect against Potassium bromate-induced dyslipidaemia, increase HDL and reduce cardiovascular disease ratio.

Keywords: Cardiovascular diseases; *Corchorus olitorius* leaves; dyslipidaemia; lipid profile

1. INTRODUCTION

According to researches, medicinal plants are utilized worldwide to treat chronic illnesses [1, 2]. Several plant species in Nigeria have reportedly been utilized to cure a variety of illnesses, including dyslipidemia and its consequences [3]. Numerous kinds of medicinal plant leaves that are utilized in traditional lipid dysfunction control and therapy across the globe

have been studied [4,5]. The hypoglycaemic and hypolipidaemic effects of plant leaves used in the treatment of diabetes, are caused by the presence of phytochemicals and other bioactive components in those leaves [6]. Momo et al. [7] found that traditional leafy vegetables may improve blood lipid levels and improve carbohydrate metabolism, which may help prevent and control dyslipidemia. The health advantages of underutilized indigenous leaves with reference to lipid regulation, however, are still poorly understood [3]. *Corchorus olitorius* is one of these plants.

The vegetable plant *Corchorus olitorius* L., also referred to as "Jute mallow" is a member of the Malvaceae family, which was once known as the Tiliaceae. It is a tall, annual plant that grows well in many types of soil [8]. The second most extensively farmed vegetable fiber is jute, which comes from the Corchorus plant [9,10]. The leaves of *C. olitorius* are a traditional vegetable in Egypt and are widely used in the cuisines of Southern Asia, Africa, and the Middle East. When cooked, it takes on a mucilaginous texture. The dried leaves are used to make herbal tea, while the seeds are utilized as a flavoring agent [11]. *C. olitorius* leaves are frequently used as a vegetable in Nigerian cuisine, particularly among South-Westerners, while making the stew-based meal known as "ewedu". It is prepared as stew and is referred to as krainkrain (or craincrain) in Sierra Leone. *C. olitorius* is referred to as "saluyot" in the Philippines and is eaten as a leafy vegetable with bamboo shoots [11,12]. The therapeutic qualities of *C. olitorius* leaves have been discussed in numerous papers [13,14]. Our literature searches revealed that no studies have examined its ameliorative impact on dyslipidemia caused by potassium bromate ($KBrO_3$). Therefore, the purpose of this investigation was to determine whether *C. olitorius* leaves could prevent $KBrO_3$-induced dyslipidemia.

2. MATERIALS AND METHODS

2.1 Extraction of Plant Materials

Fresh *Corchorus olitorius* (jute) plants were harvested from the Institute of Agricultural Research and Training, Moor Plantation, Ibadan, Nigeria. Carefully separating the leaves from the stem, the damaged ones were discarded. To get rid of contaminants, they were thoroughly washed under running water. In an open laboratory setting, they were allowed to air dry for 14 days at room temperature before being ground into powder with an electric blender. The extraction was performed using a soxhlet device and ethanol as the solvent in accordance with the procedures outlined by Airaodion et al. [15,16]. After the procedure was complete, the ethanol was evaporated in a rotary evaporator at 35 ^{o}C, yielding 2.28 g for a 9.12% yield as a percentage. Until it was needed, the extract was kept in the refrigerator.

2.2 Experimental Animals

The experiment involved twenty-four (24) mature male Wistar rats (*Rattus norvegicus*) weighing between 140 and 160 g. They were allowed to be used to a laboratory environment for seven (7) days before the test. The rats were kept in cages made of wire mesh, and they had unrestricted access to commercial rat food and water. The animals were housed at regular temperatures and humidity levels with 12-hour light and dark cycles. The Declaration of Helsinki and the rules set by the Committee for the Control and Supervision of Experiments on Animals were followed in conducting this investigation. Additionally, NIH policy was followed when doing animal experiments [17]. They were divided into groups A, B, C, and D at random. Group A received oral distilled water, served as the control group. In addition to the 100 mg/kg body weight of potassium bromate given to groups B, C, and D, animals in groups C and D also received 100 and 200 mg/kg body weight of *C. olitorius*, respectively. Oral gavage was used to administer *C. olitorius* extract and freshly made potassium bromate to rats every day for 28 days. Twenty-four hours after the last treatment, the animals were killed under gentle sedation with diethyl ether. Blood was drawn by puncturing the heart.

2.3 Preparation of Organ homogenate

The animals were quickly dissected and the organs (heart) were extracted. Then, 10% of each organ homogenate was created in 6.7mM potassium phosphate buffer using a Teflon homogenizer (pH 7.4). The homogenate was centrifuged at 10,000 rpm for 10 minutes at 40°C to separate the homogenate into a clear supernatant that could be kept in the freezer for additional analysis.

2.4 Determination of Lipids

Lipids were isolated and quantified using the techniques previously reported [18,19]. Coronary heart disease (CHD) risk ratio was determined as the ratio of total cholesterol to high density lipoprotein.

2.5 Statistical Analysis

Graph Pad Prism was used to perform a variance analysis on the data. The outcomes were shown as Mean±Standard Deviation (SD). The means were compared using both Tukey's post hoc analysis and one-way analysis of variance (ANOVA). At $P \leq 0.05$, differences between means were deemed statistically significant.

3. RESULTS

In comparison to the untreated group, the research animals given $KBrO_3$ had considerably higher plasma levels of total cholesterol, triglycerides, LDL, VLDL, and the CHD risk ratio, whereas their levels of HDL and the HDL/LDL ratio were much lower (table 1). When compared to the control group, treatment with $KBrO_3$ significantly decreased cardiac levels of total cholesterol, HDL, and HDL/LDL ratio, while increasing levels of triglycerides, LDL, and VLDL as well as the CHD risk ratio. *C. olitorius* reduced these abnormalities in a dose-dependent manner.

Table 1: Effect of *C. olitorius*on the Plasma Lipid Profile of Potassium Bromate-induced Dyslipidemia

Lipid Profile	Control	$KBrO_3$ Only	$KBrO_3$ + 100 mg/kg *C. olitorius*	$KBrO_3$ + 200 mg/kg *C. olitorius*	p-value
TC (mg/dL)	148.32±8.25	232.42±12.35	218.34±12.32	173.83±8.83	0.01
TG (mg/dL)	96.46±6.22	171.37±8.26	154.82±6.89	114.27±8.17	0.00
HDL-C (mg/dL)	49.46±3.26	32.28±5.36	33.73±4.18	45.21±3.25	0.02
LDL-C (mg/dL)	47.24±1.48	74.26±3.17	69.27±5.55	52.64±3.73	0.03
VLDL-C (mg/dL)	19.29±1.72	34.27±3.44	30.96±3.24	22.85±1.84	0.02
HDL:LDL ratio	1.04±0.06	0.43±0.01	0.48±0.02	0.85±0.03	0.01
CHD risk ratio	2.30±0.35	7.20±0.27	6.47±1.01	3.84±0.41	0.01

Values are presented as Mean±SD, where n = 6.

Legend: TC = Total Cholesterol, TG = Triglyceride, HDL-C = High Density Lipoprotein Cholesterol, LDL-C = Low Density Lipoprotein Cholesterol, VLDL-C =Very Low Density Lipoprotein Cholesterol, CHD = Coronary Heart Disease

Table 2: Effect of *C. olitorius*on the Heart Lipid Profile of Potassium Bromate-induced Dyslipidemia

Lipid Profile	Control	$KBrO_3$ Only	$KBrO_3$ + 100 mg/kg *C. olitorius*	$KBrO_3$ + 200 mg/kg *C. olitorius*	p-value
TC (mg/dL)	116.46±3.38	81.20±7.82	83.27±3.33	89.37±3.25	0.03
TG (mg/dL)	136.28±3.01	159.77±9.32	157.45±3.33	152.28±4.24	0.03
HDL-C (mg/dL)	58.29±2.15	38.31±2.94	43.93±2.00	52.24±2.78	0.01
LDL-C (mg/dL)	46.86±2.02	59.20±3.22	55.28±1.93	51.38±2.45	0.03
VLDL-C (mg/dL)	27.25±2.46	31.95±3.24	31.49±2.31	30.45±2.46	0.04
HDL:LDL ratio	1.24±0.03	0.64±0.02	0.79±0.01	1.01±0.01	0.02
CHD risk ratio	2.00±0.10	2.11±0.09	1.90±0.05	1.71±0.07	3.24

Values are presented as Mean±SD, where n = 6.

Legend: TC = Total Cholesterol, TG = Triglyceride, HDL-C = High Density Lipoprotein Cholesterol, LDL-C = Low Density Lipoprotein Cholesterol, VLDL-C = Very Low Density Lipoprotein Cholesterol, CHD risk ratio = Coronary Heart Disease Risk Ratio

4. DISCUSSION

Jute leaf is a green leafy vegetable that is frequently consumed and used in traditional medicine to treat different ailments. At the moment, dietary control is still one of the best ways to prevent and treat chronic degenerative diseases like type 2 diabetes and cardiovascular conditions. The current study examined the levels of lipidaemia in various experimental groups. Animals exposed to $KBrO_3$alone had significantly higher plasma levels of triglycerides (TG), total cholesterol (TC), and low density lipoprotein cholesterol (LDL-C), whereas their levels of high density lipoprotein cholesterol (HDL-C) were much lower when compared with those in the untreated group. An increasing body of research shows that while high HDL-C is cardioprotective, elevated plasma triglyceride concentrations, LDL-C, and ratios of TG/HDL-C and TC/HDL-C are markers of increased cardiovascular (CV) risk. The increased plasma triglyceride concentration seen in the group treated with $KBrO_3$ may have resulted from either excessive generation or underutilization of triglycerides [23].

It is generally known that plasma insulin plays a significant part in lipid metabolism. Although plasma insulin was not assessed in this research, it may be hypothesized that the treatment with both extracts resulted in decreased insulin secretion from pancreatic cells, which may have contributed to the raised triglyceride and LDL-C levels in this study [24]. Itwas noted that TC/HDL-C (CHD risk) ratio greater than 5 is the most potent independent predictors of the onset of coronary artery disease [25,26]. In this study, $KBrO_3$ exposure increased the CHD risk ratio from 2.30 to 7.20 in the plasma of experimental rats. This is an indication that $KBrO_3$ intoxication could greatly lead to coronary artery disease.

Compared to animals treated with only $KBrO_3$, those concurrently given *C. olitorius* leaf extract

and $KBrO_3$ showed lower plasma and cardiac triglyceride concentrations. This suggested that *C. olitorius*leaves might have hypolipidaemic properties. A high triglyceride level has been linked to insulin insufficiency, which leads to improper glucose use and a hyperglycemic state in animals [27]. Fatty acids from adipose tissue may also be mobilized and transported to the liver [28]. The decreased plasma and cardiac triglyceride concentrations in the rats treated with 100 and 200 mg/kg body weight of *C. olitorius* may have also been caused by improved blood plasma glucose uptake and utilization, which decreased triglyceride biosynthesis and possibly decreased the mobilization of fatty acids from adipocytes. Furthermore, enhanced glucose utilization and a resulting decreased fat mobilization may be responsible for the stability of plasma triglyceride and cholesterol levels in rats after administration of the leaf extracts [7,29]. This suggests that the plant extracts might help to lessen the problems that frequently accompany with diabetes, like hyperlipidemia and hypercholesterolemia.

The elevated plasma cholesterol seen in this study could have been attributed to stimulation of HMG-CoA synthase, the rate-limiting enzyme in cholesterol biosynthesis. A decrease in the activity of acy1-CoA: cholesterol-O-acyltransferase (ACAT), the enzyme that esterifies cholesterol in body cells, may also be the cause of the $KBrO_3$-treated rats' blood cholesterol buildup [30]. A spike in the efflux of cholesterol from the liver into the blood could have also been the cause of the elevated plasma cholesterol [31]. By blocking the production of cholesterol in the liver or limiting the quantity of cholesterol taken into the bloodstream through the gastrointestinal tract, *C. olitorius*leaves most likely decreased the concentration of circulating plasma cholesterol.

Furthermore, compared to rats treated with $KBrO_3$ alone, rats concurrently given *C. olitorius* leaves saw a substantial reduction in plasma LDL-cholesterol levels. This implies that the leaves of *C. olitorius* may have hypocholesterolemic properties. Through their well-established effects on cellular antioxidant state and inflammation, flavonoids may have a favorable impact on health [32]. According to earlier research, drugs with hypocholesterolemic action may impair insulin production in dyslipidaemic rats, which could prevent the LDL-receptors from absorbing circulating plasma LDL-cholesterol [33]. Additionally, the fact that animals treated with 100 and 200 mg/kg body weight of *C. olitorius* leaves had higher plasma HDL cholesterol levels than animals treated with only $KBrO_3$ supports the claim made by Airaodion et al. [34] that consuming foods high in phytochemicals has protective effects on lipid profiles and cardiovascular diseases (CVD). According to this study's findings, *Corchorus olitorius* leaves have hypolipidaemic effects against $KBrO_3$-induced dyslipidemia. These findings are in line with those of Airaodion et al. [13], who examined the hypoglycemic and hypolipidaemic effects of methanolic extract of *Corchorus olitorius* leaves in albino rats. This could be because alkaloids, saponins, flavonoids, and polyphenols are present, which are known to lower plasma lipid levels in animals. The animals' dramatically elevated plasma levels of high-density lipoprotein cholesterol may have been caused by the significantly reduced total cholesterol levels sequel to administration of *C. olitorius* leaves in this study.

A highly ideal biochemical condition for the prevention of atherosclerosis and ischemic situations is a significant reduction in total cholesterol and an increase in HDL-C levels [35]. High levels of HDL-C protect against cardiovascular diseases by removing cholesterol atheroma from arteries and transporting it back to the liver for excretion or reutilization [36,37]. The fact that plasma HDL-C levels rose in animals that received $KBrO_3$ and *C. olitorius* leaf extract at the same time suggests that the vegetable had an influence on raising HDL-C levels.

Although the study did not examine the impact of $KBrO_3$ on glucose concentration, it is probable that $KBrO_3$ increased blood glucose levels.

According to several researches, experimentally-induced diabetes is associated with dyslipidemia. A recognized consequence of diabetes mellitus known as hyperlipidaemia is characterized by increased levels of phospholipids, cholesterol, and other lipoproteins [38]. According to reports, the increased mobilization of free fatty acids from peripheral fat depots as a result of the hormone sensitive lipase's inhibition is what causes elevated plasma lipid levels in people with diabetes [39]. The extra fatty acids produced are converted into phospholipids and cholesterol, which are then released into the blood as lipoproteins along with extra triacylglycerols that were produced concurrently in the liver. As a result, it is possible to interpret the marked hyperlipidemia seen in $KBrO_3$-exposed rats as the result of unchecked actions of lipolytic hormones in fat depots [40]. Concurrent administration of *C. olitorius* leaves and $KBrO_3$ reduced each of these effects.

The chemical analysis of *C. olitorius* leaves revealed that they contain phenolic, glycoside, and flavonoid compounds [41]. Therefore, the hypolipidemic effect of *C. olitorius* leaves observed in this study may be caused by these chemical constituents. These results raise the possibility that *C. olitorius* leaves may inhibit platelet aggregation and increase vasodilatation, acting as a significant protective factor in preventing the onset and progression of vascular complications brought about by the hyperlipidemic state. Studies have actually demonstrated that polyphenolic compounds, which are present in some plant foods, can inhibit the formation of thrombi [42,43]. There have also been reports of a number of other plants and extracts having antihyperlipidaemic and insulin-stimulating properties [44–46]. Metabolites like glycosides, alkaloids, and flavonoids have been discovered to be present in the majority of plants with these properties [47–49].

5. CONCLUSION

The study showed that $KBrO_3$ caused increased levels of triglycerides, LDL, VLDL and also increase CHD risk ratio and reduced HDL. *Corchorus olitorius* was found to reduce this lipid abnormality induced by $KBrO_3$.

REFERENCES

1. Airaodion AI, Ogbuagu EO, Ekenjoku JA,Ogbuagu U, Airaodion EO. Therapeutic effect of methanolic extract of *Telfairia occidentalis* leaves against acute ethanol-induced oxidative stress in Wistar rats. International Journal of Bio-Science and Bio-Technology. 2019; 11(7):179-189.
2. 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.
3. Ogbuagu EO, Unekwe PC,Airaodion AI, Nweke IN, Ogbuagu U. Hypolipidemic propensity of ethanolic extract of *Xylopia aethiopica* fruit in Wistar rats. Asian Journal of Research in Cardiovascular Diseases. 2020;3(5):1-11.
4. Ogbuagu EO, Airaodion AI, Okoroukwu VN, Ogbuagu U. Hyperglycemic and hypocholesterolemic effect of monosodium glutamate in Wistar rats. International Journal of Research and Reports in Hematology. 2019;2(3):1-7.
5. Gondwe M, Kamadyaapa DR, Tufts MA, Chuturgoon, AA, Ojewole, JAO, Musabayane CT. Effects of Persea Americana Mill (Lauraceae) (Avocado) ethanolic extract on blood glucose and kidney function in streptozotocin-induced diabetic rats and on kidney cell lines of the proximal (LLCPK 1) and distal tubules (MDBK). Meth, Find. Exp. Clin. Pharmacol.2008;30:25-35.
6. Obadoni BO, Ochuko PO. Phytochemical studies and comparative efficacy of the crude extracts of some Homostatic plants in Edo and Delta States of Nigeria. Global

Journal of Pure Applied Science. 2001;8b:203-208.
7. Momo CEN, Oben JE, Tazoo D, Dongo E. Antidiabetic and hypolipidemic effects of Laporteaovalifolia (urticaceae) in alloxan-induced diabetic rats. African Journal of Traditional Medicine. 2006;3: 36-43.
8. Ezirim EO, Ugwu CN, Uche CL, Abali IO,Onyekachi OIN, Nwobodo MU, Chika-Igwenyi NM, Onyeaghala CA, Aguh KJ, Agu FU, Orji SF, Igwenyi C, Airaodion AI. Effect of *Corchorus olitorius*leaves on sex hormones of animals induced with potassium bromate. International Journal of Chemical & Life Science, 2022; 11(10): 22-31
9. Velempini P, Riddoch I, Batisani N. Seed treatments for enhancing germination in wild okra (*Corchorus olitorius*). Experimental Agriculture.2003; 39(4): 441-447.
10. Adegoke AA, Adebayo-Tayo BC. Phytochemical composition and antimicrobial effects of *Corchorousolitorius*leaf extracts on four bacterial isolates. Journal of Medicinal Plant Research. 2009; 3(3): 155-159.
11. Mahbubul MI. Biochemistry, medicinal and food values of Jute (*Corchorus capsularis* L. and *C. olitorius*L.) leaf: a review. International Journal ofEnhanced Research inScience, Technology andEngineering. 2013; 2(11): 35-44.
12. Abdul S, Kaushik C. Jute-A biological elixir with multifaceted applications: An overview. International Journal of Research in Pharmaceutical Sciences. 2015; 6(4): 323-332.
13. Airaodion AI, Akinmolayan JD, Ogbuagu EO, Airaodion EO, Ogbuagu U, Awosanya OO. Effect of methanolic extract of *Corchorus olitorius* leaves on hypoglycemic and hypolipidaemic activities in albino rats. Asian Plant Research Journal. 2019;2(7):1-13.
14. Airaodion AI, Ogbuagu EO, Ewa O, Ogbuagu U, Awosanya OO, Adekale OA. Ameliorative efficacy of phytochemical content of *Corchorus olitorius*leaves against acute ethanol-induced oxidative stress in Wistar rats. Asian Journal of Biochemistry, Genetics and Molecular Biology. 2019;2(2): 1-10.
15. Airaodion AI, Ogbuagu EO, Ogbuagu U, Adeniji AR, Agunbiade AP, and Airaodion EO. Hepatoprotective effect of *Parkia biglobosa* on acute ethanol-induced oxidative stress in Wistar rats. International Research Journal of Gastroenterology and Hepatology. 2019;2(1): 1-11.
16. Airaodion AI, Ngwogu AC, Ekenjoku JA, Ngwogu KO. Hepatoprotective potency of ethanolic extract of *Garcinia kola* (Heckel) seed against acute ethanol-induced oxidative stress in Wistar rats. International Research Journal of Gastroenterology and Hepatology. 2020;3(2): 1-10.
17. National Research Council. Guide for the Care and Use of Laboratory Animals, 8th ed.; The National Academies Press: Washington, DC, USA, 2011.
18. Owoade AO, Adetutu A, Airaodion AI, Ogundipe OO. Toxicological assessment of the methanolic leaf extract of *Brideliaferrugelia*. The Journal of Phytopharmacology. 2018;7(5):419-424.
19. 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.
20. 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.
21. Airaodion AI, Ogbuagu EO, Ekenjoku JA, Okoroukwu VN, Ogbuagu U. Bigi soft drinks might induce hyperglycemia and hyperlipidemia in Wistar rats. International Journal of Research and Reports in Hematology. 2019;2(4):1-10.
22. Airaodion AI, Ogbuagu U, Ekenjoku JA, Ogbuagu EO, Airaodion EO. Hyperglycemic and hyperlipidemic effect of some coca-cola soft drinks in Wistar rats. Acta Scientific Nutritional Health. 2019;3(12):114-120.

23. Njoku OC, Airaodion AI, Ekenjoku JA, Okoroukwu VN, Ogbuagu EO, Nwachukwu N, Igwe CU. Antidiabetic potential of alkaloid extracts from *Vitex doniana*and *Ficus thonningii*leaves on alloxan-induced diabetic rats. International Research Journal of Gastroenterology and Hepatology. 2(2): 1-12
24. Airaodion AI, Ogbuagu EO. Effect of consumption of garri processed by traditional and instant mechanical methods on lipid profile of Wistar rats. Asian Journal of Research and Reports in Gastroenterology2020;3(1): 26-33
25. Andallu B, Kumar AVV, Varadacharyulu NC. Lipid abnormalities in streptozotocindiabetes: Amelioration by Morusindica L. cvSuguna leaves. International Journal of Diabetes in Developing Countries. 2009;29(3):123-8. Doi: 10.4103/0973-3930.54289
26. Luz PL, Favarato D, Junior JRF, Lemos P, Chagas ACP. High ratio of triglyceride to HDL cholesterol predict extensive coronary disease. Clinics. 2008;64:427-32. doi: 10.1590/S1807-59322008000400003.
27. Ogbuagu EO, Airaodion AI, Ogbuagu U, Airaodion EO. Effect of methanolic extract of*Vernonia amygdalina*leaves on glycemic and lipidaemic indexes of Wistar rats.Asian Journal of Research in Medical and Pharmaceutical Sciences. 2019;7(3):1-14.
28. Duwaerts CC, Maher JJ. Macronutrients and adipose-liver axis in obesity and fatty liver. Cell mol Gastroenterol Hepatol. 2019; 7(4): 749-761.
29. Kwiterovich, P.O. (2000). The metabolic pathways of high-density lipoprotein, low density lipoprotein and triglycerides: A current review. *American J. Cardiology.* 86(12): 5-10.
30. Katsuren K, Tamura T, Arashiro R, Takata K, Matsuura T, Niikawa N, Ohta T. Structure of the human acyl-CoA:cholesterol acyltransferase-2 (ACAT-2) gene and its relation to dyslipidemia. *BiochimBiophys Acta.* 2001; 1531(3): 230-240.
31. Ugwu CN, Iwuoha CE, Chika-Igwenyi NM, Onyeaghala CA, Orji SF, Igwenyi C, Uche CL, Onyekachi OIN, Nwobodo MU, Abali IO, Airaodion AI. Chemotherapeutic Propensity of Africa locust bean (*Parkia biglobosa*)Seed on Lipid Profile against Potassium Bromate-induced cardiotoxicity. Journal of Applied Life Sciences International, 2022;25(5):29-38.
32. Bao L, Hu L, Zang Y, Wang Y. Hypolipidemic effects of flavonoids extracted from *lomatogoniumrotatum*. Exp Ther Med.2016;1 1(4): 1417-1424.
33. Kawai Y, Sato-Ishida R, Motoyama A, Kajinami K. Place of pitavastatin in the statin armamentarium: promising evidence for a role in diabetes mellitus. drug des develTher. 2011; 5: 283-297.
34. Airaodion AI, Adeniji AR, Ogbuagu EO, Ogbuagu U, Agunbiade AP. Hypoglycemic and hypolipidaemic activities of methanolic extract of *Talinum triangulare*leaves in Wistar rats. International Journal of Bio-Science and Bio-Technology. 2019;11(5):1-13
35. Rotimi SO, Omotosho OE,Roimi OR. Persistence of acidosis in alloxan induced diabetic rats treated with the juice of Asystasiagangetica leaves. Phcog. Mag.,2011;7:25-30
36. James DB, OwolabiOA, Ibrahim AB, Folorunsho DF, Bwalla I, Akanta F. Changes in lipid profile of aqueous and Ethanolic extract of Blighiasapida in rats. Asian Journal of Medical Science. 2010;2: 177-180
37. Airaodion AI, Akaninyene IU, Ngwogu KO, Ekenjoku JA, Ngwogu AC.Hypolipidaemic and antidiabetic potency of *Allium cepa* (onions)bulb in alloxan-induced diabetic rats. Acta Scientific Nutritional Health. 2020;4(3): 1-8.
38. Ayinla MT, Dada SO, Shittu ST, Olayaki LA,Akiode AO, Ojulari SL. Anti-hyperlipidemic effect of aqueous leaf extract of *Ocimumgratissimum* in alloxan-induced diabetic rats. International Journal of Medicine and Medical Science. 2011;3(12):360-363.
39. Sharma S, Nasir A, Prabhu KM, Murthy PS, Dev G. Hypoglycaemic and hypolipidaemic effect of ethanolic extract of seeds of

Eugenia jambolana in alloxan induced diabetic rats. Ethnopharmacology. 2010;85: 201- 206.
40. Odetala AA, Akinloye O, Egunjobi C, Adekunlea WA,Ayoola AO. Possible antidiabetic and antihyperlipidemic effect of fermented *Parkiabiglobosa* (JACQ) extract in alloxan-induced diabetic rats. Clinical Experimental Pharmacology and Physiology2006;33: 808-812.
41. Orieke 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.
42. Dohadwala MM, Vita JA. Grapes and cardiovascular disease. *Journal of Nutrition*. 2009;139(9):1788–1793.
43. 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.
44. Airaodion AI, Ogbuagu EO, Airaodion EO, Ekenjoku JA, Ogbuagu U. Pharmacotherapeutic effect of methanolic extract of *Telfairiaoccidentalis* leaves on glycemic and lipidemic indexes of alloxan-induced diabetic rats. International Journal of Bio-Science and Bio-Technology. 2019;11(8):1-17.
45. Airaodion AI, Ogbuagu EO, Ekenjoku JA, Ogbuagu U, Okoroukwu VN. Antidiabetic effect of ethanolic extract of *Carica papaya* leaves in alloxan-induced diabetic rats. American Journal of Biomedical Science & Research. 2019;5(3):227-234.
46. Megwas AU, Akunne PN, Oladosu NO, Alabi OJ, Njoku OC, Airaodion AI. Effect of Bambara Nut Consumption on Blood Glucose Level and Lipid Profile of Wistar Rats. International Journal of Research and Reports in Hematology. 2021;4(1):30-41.
47. 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 *Parquetinanigrescens*leaves. Asian Plant Research Journal. 2019;2(3):1-14.
48. 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 *Ocimumgratissimum*and *Telfairia occidentalis* Leaves. Asian Journal of Research in Medical and Pharmaceutical Sciences. 2019; 7(1):1-11.
49. Loew S, Kaszkin M. Approaching the problem of bioequivalence of herbal medicinal products. Phytother. Res. 2002;16:705–711.