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Phytochemical, Hypolipidemic, and Lipid Peroxidation Inhibitory Activities of Ethanol Extract of *Tetrapleura tetraptera* Fruit in Albino Rats Intoxicated with Carbon Tetrachloride

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Abstract

The fruits of *Tetrapleura tetraptera*, belonging to the Fabaceae family, have long been used in traditional medicine for managing various health conditions. This study aimed to investigate the phytochemical composition, hypolipidemic effects, and lipid peroxidation inhibitory properties of the ethanol extract of *Tetrapleura tetraptera* fruit in albino rats intoxicated with carbon tetrachloride (CCl4). Proximate composition, qualitative and quantitative phytochemical analysis, acute toxicity, lipid profiles, and lipid peroxidation inhibition activities were determined using standard methods. Thirty albino rats were randomly assigned to six groups of five rats each. The proximate composition of the whole fruit revealed the following (%): moisture (17.07), ash (17.17), lipid (10.10), fiber (5.26), protein (15.77), carbohydrate (34.62), and caloric value (1222.28 kJ/100g). Phytochemical analysis revealed the presence of flavonoids, phenolics, saponins, tannins, alkaloids, terpenoids, steroids, coumarins, glycosides, and amino acids. Quantitative analysis showed varying levels of bioactive compounds, including flavonoids (0.08 ± 0.004), phenolics (0.38 ± 0.09), saponins (6.07 ± 1.01), and others. CCl4-induced intoxication led to hyperlipidemia, with elevated serum levels of total cholesterol (TC), triacylglycerol (TAG), and low-density lipoprotein (LDL), while high-density lipoprotein (HDL) levels decreased. Treatment with *Tetrapleura tetraptera* fruit extract (100, 300, 500 mg/kg) significantly ($P < 0.05$) reduced serum TC, TAG, and LDL levels and increased HDL. Additionally, serum malondialdehyde (MDA) levels were significantly higher in the CCl4 group but decreased significantly with treatment. These findings suggest that *Tetrapleura tetraptera* fruit extract exhibits promising hypolipidemic and antioxidant effects, supporting its traditional use in managing conditions like inflammation, cardiovascular disorders, and diabetes mellitus.

Keywords: *Tetrapleura tetraptera*; Hyperlipidemia; Phytochemicals; Lipid Peroxidation; Ethanol Extract and Carbon Tetrachloride

1. Introduction

Cholesterol is one of the components of cell membranes and functions in the regulation of membrane fluidity and permeability. Cholesterol acts as a precursor for the synthesis of bile acid, steroid hormones and vitamin D (Boutari et al., 2021). Consequently, it is of basic significance that the cells of major tissues of the body be guaranteed a continuous supply of cholesterol. However, a diet rich in cholesterol tends to induce free radical production followed by hypercholesterolemia, which is a major risk factor of atherosclerosis. Changes in the modern diet of humans have led to

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a gradual increase in diseases related to abnormal lipid metabolism (Boutari et al., 2021). Hyperlipidemia is a chronic condition characterized by lipid metabolism abnormalities, posing a significant risk for cardiovascular diseases, hypertension, type 2 diabetes, and certain cancers (Kemigisha et al., 2018). It is a major public health concern due to its increasing prevalence and impact on mortality rates and quality of life (Feldman et al., 2021). It is a disorder in which abnormal lipid metabolism results in a higher-than-normal level of one or more lipids in the serum, and the common symptoms are high levels of total serum cholesterol (TC), triacylglycerols (TAG), and low-density lipoprotein cholesterol (LDL-C) or low levels of high-density lipoprotein cholesterol (HDL-C) (Boden et al., 2020). Hyperlipidemia can cause some serious cardiovascular diseases, such as coronary heart disease, which are responsible for millions of deaths in the world every year (Abbas et al., 2017). Amazingly, a study of early subclinical atherosclerosis revealed that 63% of participants have symptoms of subclinical atherosclerosis. Although considerable progress has been made in the treatment of hyperlipidemia, the incidence rate and risk associated with this disease are still rising (Gong et al., 2020). Therefore, the prevention and treatment of hyperlipidemia are enormously important. Presently, the main treatment of hyperlipidemia is man-made drugs, and the classical lipid-lowering drugs include statins, fibrates, and nicotinic acids (Zhang et al., 2020). Hyperlipidemia is a risk factor for diseases such as nonalcoholic fatty liver disease (NAFLD), atherosclerosis, diabetes, cerebral infarction, acute myocardial infarction, and acute pancreatitis (Mach et al., 2019). Hypolipidemic drug is any agent that reduces the level of lipids and lipoproteins in the blood. Lipoproteins bind cholesterol and can accumulate in blood vessels. High levels of specific lipoproteins, namely, low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL), have been associated with an elevated risk of certain forms of cardiovascular disease, including coronary artery disease, heart attack, and stroke (Fernandez-friera et al., 2015). Statins are hypolipidemic drugs that block the enzyme HMG-CoA (5-hydroxy-3-methylglutaryl-coenzyme A) reductase, which is required for the synthesis of cholesterol. Statins are generally quite safe, but side effects may include muscle pain and fatigue (Stringer, 2024). Examples of statins include simvastatin, pravastatin, and lovastatin.

Lipid peroxidation is the oxidative deterioration of lipids containing a number of carbon-carbon double bonds (Toori *et al.,* 2015). It is a metabolic process under normal aerobic conditions and is one of the highly investigated consequences of Reactive Oxygen Species (ROS) action on membrane structure and function (Erukainure et al., 2017). Polyunsaturated fatty acids (PUFA), are subject to peroxidation (Saliu et al., 2021). Hydroxyl group (OH) can react with the methylene groups of PUFA forming conjugated dienes, lipid peroxy radicals (LOOP), and hydroperoxides (LOOH) (Moukette et al., 2015). The lipid hydroperoxides produced can undergo reductive cleavage by reduced metals such as Fe^{2+} and produce lipid alkoxyl radical which can initiate additional chain reactions (Irondi et al., 2015). The final stable products of peroxidation are aldehydes which react with thiobarbituric acid (TBA) to form TBA-malonaldehyde adduct with an absorbance maximum at 532 nm (Ogunlakin and Sonibare, 2024). Malondialdehyde (MDA) is a marker of lipid peroxidation following damage by reactive oxygen species. These are formed by enzymatic or non-enzymatic reactions involving free radicals. A large number of toxic by-products are formed during lipid peroxidation (Toori *et al.,* 2015). These have effects at a site away from area of their generation. Hence, they behave as toxic 'second messengers'. Membrane lipids are particularly susceptible to lipid peroxidation. Since membranes form the foundation of many cellular organelles like mitochondria, plasma membranes, endoplasmic reticulum, lysosomes, peroxisomes etc., the damage caused by lipid peroxidation is highly harmful to the functioning of the cell and its survival (Soumen, 2014). The presence of polyunsaturated fatty acids (PUFAs) in the phospholipids of the bilayer of biological membranes is the basis of their critical feature of fluidity. Since lipid peroxidation attacks the components that impart these properties, it affects the biophysical properties of membranes (Soumen, 2014). Lipid peroxidation decreases the membrane fluidity, changes the phase properties of the membranes and decreases electrical resistance. Also, cross-linking of membrane components restricts mobility of membrane proteins.

Carbon tetrachloride (CCl_4) is a potent hepatotoxin used in the induction of toxicity in experimental models (Zarezade *et al.* (2018). It is metabolized by cytochrome P_{450} to trichloromethyl and trichloromethyl peroxyl radicals (Wang *et al.,* 2014). These trichloromethyl radicals bind to tissue macromolecule and induce peroxidative degradation of membrane lipids of the endoplasmic reticulum which are rich in polyunsaturated fatty acids (Brai *et al.,* 2014). This development ultimately lead to the formation of lipid peroxides that in turn yield other products, among which is malondialdehyde (MDA). These products cause membrane injury and consequently damage the liver (Wang *et al.,* 2014). Liver injury induced by CCl_4 is usually employed as a model for testing hepatoprotective drugs. CCl_4 –induced hepatotoxicity involves two phases. In the initial phase, the metabolism of CCl_4 by cytochrome P_{450} to the trichloromethyl radicals occurs (Ugwah-Oguejiofor *et al.,* 2018). These free radicals bind to lipoprotein and lead to peroxidation of lipids of the endoplasmic reticulum which causes changes in the physical and chemical properties of cellular membranes, thus affecting their fluidity and permeability for ion exchange, resulting in leakage of enzymes in blood and eventually resulting in swelling, cytolysis and cell death (Zarezade *et al.,* 2018). The second phase involves the activation of kupffer cells, which is followed by the production of pro-inflammatory mediators.

Tetrapleura tetraptera belongs to the Mimosaceae family. It is locally known as Osakirisa or Oshosho in Igbo (Ojewole and Adewunmi, 2004). It is called "Prekese" in the Twi language of Ghana (Famobuwa et al., 2016). It is generally found in the lowland forest of tropical Africa. The plant is valued in Eastern, Southern and Western Nigeria and beyond for its nutritional and pharmacological properties due to a number of active nutrients. The fruits consist of a freshly pulp with small, brownish – black seeds. Its fruit is used for the management of convulsions, leprosy, inflammation, and rheumatism. (Adusei et al., 2019; Ojewole and Adewumi, 2004). The fruits contain oily, aromatic and sugary substances when the fruits drop as red brown pods, their smell attracts insects, termites, animals and even humans who need them for food and other uses. The fruit is used to prepare soup for mothers from the first day of birth to prevent post partum contraction (Mbaveng et al., 2021). Korang et al., 2019 reported the effectiveness of the ethanol extract as a fungus agent. The leaves are essential for the treatment of epilepsy and present strong molluscicidal activity (Ajayi et al., 2011; Tsala et al., 2014). The aqueous fruit extract has also been shown to possess hypoglycaemic properties (Ojewole and Adewunmi, 2004; Adusei et al., 2019). The root extract has also been proven to be used for the treatment of gastrointestinal related clinical problems (Noamesi et al., 1994; Saliu et al., 2021). Ethnomedically, all parts of *Tetrapleura tetraptera* have been reported to be used for medicinal purposes (Saliu et al., 2021; Lin et al., 2019). Although, literature revealed that anti-oxidant activities are essential for protective activities of the cell, no information was found regarding lipid peroxidation inhibitory activities of fruit extract of *Tetrapleura tetraptera*. **The present study aimed to evaluate the phytochemical profile, hypolipidemic effects, and lipid peroxidation inhibitory activities of the ethanol extract of *Tetrapleura tetraptera* fruit in albino rats.**

2. Material and Methods

2.1. Plant Material

The plant material are the fruits of *Tetrapleura tetraptera*.

2.2. Methods

2.2.1. Collection, Preparation and Extraction of plant fruit

The plant material, (*Tetrapleura tetraptera*) fruit were purchased from Mile One market, Port-Harcourt, Rivers State, Nigeria. The fruit samples were identified and authenticated by Mr. Alfred Ozioko of the Bioresources Development and Conversation Programme (BDCP), University of Nigeria, Nsukka, Enugu State. The specimen (*Tetrapleura tetraptera*) fruit voucher number is InterCEDD/085. They were thoroughly washed and air-dried for four weeks. The air-dried fruits were weighed using electronic weighing balance and milled with automatic electrical blender to powdered form and with weight of (731.81 g). The milled plant sample was later soaked for 72 hr at room temperature with 90% ethanol. After 72 hr, it was filtered using cheese cloth and then filtered through Whatmann 1 filter paper. The filtrate was concentrated using a water bath at a temperature of 47^0C. After filtration, the filtrate was stored in an airtight container in a refrigerator until use.

2.2.2. Proximate analysis of whole sample of Tetrapleura tetraptera fruit

The whole sample of *Tetrapleura tetraptera fruit* were analyzed for proximate composition using standard analytical methods by AOAC, 2005.

Calorific Value Determination

Caloric value of whole sample of *Tetrapleura tetraptera* fruit was determined using the method of James, (2019).

Energy or Caloric Value (KJ/100g) = (Protein X 16.7) + (Lipids X 37.7) + (Carbohydrate X 16.7)(James, 2019)

2.2.3. Qualitative Phytochemical Screening of Tetrapleura tetraptera fruit

Phytochemical analysis of the *Tetrapleura tetraptera* fruit were carried out using the method described by (Odebiyi and Sofowora, 1978) for the detection of saponins, tannins, phenolics, alkaloids, steroids, triterpenes, phlobatannins, glycosides and flavonoids.

- **Xanthoproteic Reaction Test:** To five (5 ml) of sample filtrate was added few drops of Conc. HNO_3. Protein was indicated by development of yellow colour which changed when alkali was added.
- **Biuret Test:** A crystal of copper sulphate was added to 2 ml of the sample filtrate and 2 drops of potassium hydroxide added. A purple colour showed the presence of proteins.

2.2.3.1 Experimental Animals

Wistar albino rats weighing 150 – 250 g were obtained from the animal house of the Madonna University, Nigeria. The rats were housed in well-ventilated laboratory cages in the animal house of the Department of Biochemistry, Madonna University, Elele campus, Nigeria. They were acclimatized to the laboratory environment for a period of seven days under standard environmental conditions, with a 12-hour light/dark cycle and allowed access to standard animal feed and drinking water *ad libitum.*

2.2.4. Toxicity Studies

Acute Toxicity Test

The mean lethal dose (LD_{50}) for ethanol extract of *Tetrapleura tetraptera* fruit were determined following the method described by Lorke, 1983.

2.2.5. Experimental Design

A total of thirty (30) male adult wistar albino rats weighing between 150 g – 250 g were selected and used for the study. They were randomly divided into six (6) groups of five (5) wistar albino rats each. A suspension of the extract was prepared in Tween - 80 and different doses of ethanol extract of *Tetrapleura tetraptera* fruit (100, 300, 500 mg/kg body weight) were administered to the animals for 14 consecutive days.

Carbon Tetrachloride (CCl_4) – Induced toxicity

Cell and tissue injury was induced in rats with a dose of 1.0 ml/kg body weight of CCl_4 (Aromose *et al*., 2018). Carbon tetrachloride (CCl_4) in its undiluted form was dissolved in olive oil in the ratio of 1:1 (v/v) prior to administration to all groups with the exception of normal control group.

- Group 1:Normal control (Distilled water only)
- Group 2: (Carbon tetrachloride, CCl_4 (1.0 ml/kg body weight)
- Group 3: 100 mg/kg body weight of *Tetrapleura tetraptera* fruit extract+ (CCl_4)
- Group 4: 300 mg/kg body weight of *Tetrapleura tetraptera* fruit extract+(CCl_4)
- Group 5: 500 mg/kg body weight of *Tetrapleura tetraptera* fruit extract+(CCl_4)
- zGroup 6: (Standard control): 100 mg/kg body weight of Silymarin + (CCl_4)

The animals were administered ethanol extract of *Tetrapleura tetraptera* fruit from day 1 to 12, and were injected with a double dose of carbon tetrachloride via intra-peritoneal route on days 13 and 14 before sacrifice. On Day 14, the animals were sacrificed following an overnight fast and blood samples collected via occular puncture with sterile syringes directly into neatly labelled plain sample tubes.

2.2.6. Preparation of Silymarin, the Standard Drug

A dose, 100 mg/kg body weight of silymarin was dissolved in 100 ml of distilled water. This was given orally to the animal's base on their individual weight using intubation cannular.

2.2.7. Serum and Tissue Preparation

After 24 hr CCl_4 administration, all animals were euthanized by diethyl ether and blood samples were collected promptly from occular puncture. The collected blood samples were centrifuged at 2500 rpm at room temperature for 20 minute and serum was separated. The serum was carefully pipetted into another set of sterile plain tubes and stored in the refrigerator for further biochemical analyses.

2.3. Lipid Profile Tests

2.3.1. Determination of Total Cholesterol Concentration

The concentration of total cholesterol was determined using the method of Abell *et al.,* (1952).

Principle

Cholesterol concentration was determined after enzymatic hydrolysis and oxidation. The indicator quinoneimine is formed from hydrogen peroxidase and 4-aminoantipyrine in the presence of phenol and peroxidase.

Test procedure

Three (3) test tubes were set up in a test tube rack and labeled blank, standard and sample respectively. To the blank, was added 10 µl distilled H_2O, 10 ul standard specimen to the standard test tube and 10 µl sample (serum) to the sample test tube. To each of these test tubes was added 1000 µl of the cholesterol reagent. It was thoroughly mixed and incubated for 10 minute at room temperature (20 - 25^{0}C). The absorbance of the sample (A sample) against the blank was taken within 60 minute at 500 nm.

$$\text{Conc. of cholesterol in sample } \left(\frac{\text{mg}}{\text{dl}}\right) = \frac{\Delta\text{Asamplex conc. of standard}}{\Delta\text{Astandard}}$$

Where Concentration of the standard = 202.65 mg/dl

2.3.2. Determination of Low-Density Lipoprotein Concentration

The concentration of low-density lipoprotein (LDL) was determined using the method of Friedwald *et al.* (1972).

Calculation

LDL-C (mg/dl) = Total Cholesterol –High Density Lipoprotein – Triglyceride/5

2.3.3. Determination of High-Density Lipoprotein Concentration

The concentration of high-density lipoprotein (HDL) was determined using the method of Toth *et al*. (2013).

Principle

LDL and VLDL (low and very low density lipoproteins) are precipitated from serum by the action of a polysaccharide in the presence of divalent cations. Then, high density lipoproteins (HDL) present in the supernatant is determined.

Procedure

The precipitant solution (0.1 ml) was added to 0.3 ml of the serum sample and mixed thoroughly and allowed to stand for 15 minute. This was centrifuged at 2,000 x g for 15 minute. The cholesterol concentration in the supernatant was determined.

Calculation

$$\text{Concentration of HDL cholesterol in sample} = \frac{\Delta\text{Asample x concentration of Standard}}{\Delta\text{ Astandard}}$$

Where concentration of the standard = 52.5 mg/dl

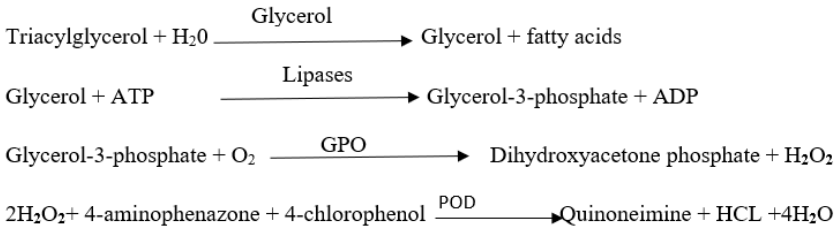
2.3.4. Determination of Triacylglycerol Concentration

The concentration of triacylglycerol (TAG) was determined using the method of Otvos (1999).

Clinical significance

Triacylglycerol measurements are used in the diagnosis and treatment of diseases involving lipid metabolism and various endocrine disorders e.g diabetes mellitus, nephrosis and liver obstruction.

The triacylglycerols are determined after enzymatic hydrolysis with lipases. The indicator is a quinoneimine formed from hydrogen peroxide, 4-aminophenazone and 4-chlorophenol under the catalytic influence of peroxidase.



- **Method**: A quantity of the sample (0.1 ml) was pipetted into a clean labelled tube and 1.0 ml of trichloroacetic acid (TCA) was added to it, mixed and then centrifuged at 250 rpm for 10 minutes. The supernatant was decanted and reserved for use. The assay procedure was carried out as shown below. Three test tubes were set up and labelled as blank, standard and sample. To the blank test tube was added distilled water (0.5 ml), TCA (0.5 ml) and reagent mixture (1 ml). To the standard tube was added, standard solution (0.5 ml), TCA (0.5 ml) and reagent mixture (1 ml) while the sample tube was filled with 1 ml of the supernatant and 1ml of the reagent mixture. The mixtures were allowed to stand for 20 minutes at 25 ^{0}C and the absorbance of the sample and standards read against the blank was taken at 540 nm.

- **Calculation**: The concentration of triacylglycerol in serum was calculated as follows:

$$\frac{\text{Absorbance of sample}}{\text{Absorbance of standard}} \text{x} \frac{\text{standard conc.}}{1} \text{ (mg/dl)}$$

Where concentration of the standard = 196 mg/dl

2.4. Determination of Malondialdehyde Concentration

Lipid peroxidation was determined spectrophotometrically by measuring the level of the lipid peroxidation product, malondialdehyde (MDA) as described by Wallin *et al.* (1993).

Principle

Malondialdehyde (MDA) reacts with thiobarbituric acid (TBA) to form a red or pink coloured complex which in acid solution absorbs maximally at 532 nm.

Procedure

To a test tube was added 0.1 ml of serum, 0.9 ml of distilled water, 0.5 ml of 25 % TCA and 0.5 ml of 1 % TBA in 0.3 % NaOH. The mixture was shaken thoroughly, incubated at 95 ^{0}C for 40 minutes and cooled in a cold-water bath. After the cooling, 0.1 ml of 20% SDS (sodium dodecyl sulphate) was added and the absorbance of the mixture determined at wavelengths of 532 nm and 600 nm against a corresponding blank. The level of lipid peroxidation (MDA concentration) was determined in terms of thiobarbituric acid reactive substances (TBARS) as follows:

$$\% \text{ TBARS} = \frac{A532 - A600}{0.5271 \times 0.1} \times 100 \quad [\text{Slope form standard curve} = y = 0.5208x \text{ (mg/ml)}]$$

2.5. Statistical Analysis

The biochemical data obtained from the study were analysed using IBM statistical product and service solutions (SPSS) version 26, and the results were expressed as Mean ± Standard Deviation. Statistical difference between means were obtained using one-way analysis of variance (ANOVA), followed by Post Hoc Multiple Comparison Test (PHMCT). ($P < 0.05$) was considered statistically significant.

3. Results

3.1. Proximate Analysis of the whole sample of *Tetrapleura tetraptera* fruit

The proximate analysis of the whole sample of *Tetrapleura tetraptera* fruit as presented in table 1 revealed that it has moisture content (17.07 ± 5.53), protein content (15.77 ± 3.11), crude fibre (5.26 ± 0.89), crude oil (10.10 ± 0.50), ash content (17.17 ± 0.82) and carbohydrate content (34.62 ± 5.84).

Table 1 Proximate Analysis of the whole sample of ***Tetrapleura tetraptera*** fruit

S/N	Proximate composition %	Composition (%)
1	Moisture Content	17.07 ± 5.53
2	Protein Content	15.77 ± 3.11
3	Crude Fibre	5.26 ± 0.89
4	Crude oil	10.10 ± 0.50
5	Ash Content	17.17 ± 0.82
6	Carbohydrate Content	34.62 ± 5.84

Results are expressed as Mean ± SD; (**n=3**).

3.1.1. Caloric Value of the whole sample of Tetrapleura tetraptera fruit

Table 2 shows that the caloric value of the whole sample of ***Tetrapleura tetraptera*** fruit was 1222.39 kj/100g.

Sample	Caloric value (KJ/100g)
Whole Sample of *Tetrapleura tetraptera* fruit	1222.39 ±79.61 (SD)

Results are expressed as Mean ± SD; (**n=3**);

3.2. Qualitative phytochemical composition of Ethanol Extract of *Tetrapleura tetraptera* Fruit

The phytochemical constituents of *Tetrapleura tetraptera* fruit extract as presented in table 3 showed that they contain relative amount of flavonoids, glycosides, phenolics, saponins, tannins, terpenoids, alkaloids, amino acids, steroids and coumarins. Glycosides, flavonoids and phenolics were detected in very small concentration. alkaloids, coumarins and amino acids were found in moderate amounts while saponins, tannins, steroids and terpenoids were detected in very high amount in the extract.

Table 3 Qualitative phytochemical composition of Ethanol extract ***Tetrapleura tetraptera*** fruit

Phytochemical Constituents	Extract composition
Phenolics	+
Saponins	+++
Tannins	+++
Flavonoids	+
Coumarins	++
Anthocyanins	N.D
Steroids	+++
Glycosides	+
Amino acid	+ +
Phlobatannin	N.D
Alkaloids	++
Terpenoids	+++

Keys: + Present in low concentration; ++ :Present in moderate concentration; +++ : Present in high concentration ; N.D : Not Detected

3.3. Quantitative Phytochemical constituents of ethanol extract of *Tetrapleura tetraptera* fruit

Table 4 presents the quantitative phytochemical analysis as flavonoids (0.08 ± 0.004), phenolics (0.38 ± 0.09), saponins (6.07 ± 1.01), tannins (3.67 ± 0.69), alkaloids (0.70 ± 0.07), terpenoids (6.51 ± 0.51), steroids (7.28 ± 0.22), coumarins (0.54 ±0.05), glycosides (0.006 ± 0.001), and amino acids (0.61 ± 0.03).

Table 4 Quantitative phytochemical constituents of ethanol extract of ***Tetrapleura tetraptera*** fruit

Quantitative Phytochemical	*Tetrapleura tetraptera* **fruit extract (mg/100g)**
Flavonoids	0.08 ± 0.004
Phenolics	0.38 ± 0.09
Saponins	6.07 ± 1.01
Tannins	3.67 ± 0.69
Akaloids	0.70 ± 0.07
Terpenoids	6.51 ± 0.51
Steroids	7.28 ± 0.22
Coumarins	0.54 ± 0.05
Glycosides	0.006 ± 0.001
Amino Acids	0.61 ± 0.03

Results are expressed as Means ± SD (n = 3); Mean values across the row are significantly different at $P < 0.05$

3.4. Acute Toxicity of ethanol extract of *Tetrapleura tetraptera* fruit

The acute toxicity studies of ethanol extract of *Tetrapleura tetraptera* fruit are shown in Table 5 below. Acute toxicity test showed no death or adverse reaction up to 5000 mg/kg body weight. There were no signs of toxicity such as reduction of locomotion, stool appearance, drowsiness, salivation, reaction to noise were not observed in animals receiving extracts in each phase.

Table 5 Phase I and II of the acute toxicity tests

Phase/Groups	**Dosage of extract (mg/kg b.w)**	**Mortality rate**
Phase 1		
Group 1	10	0/3
Group 2	100	0/3
Group 3	1000	0/3
Phase 2		
Group 1	1600	0/3
Group 2	2900	0/3
Group 3	5000	0/3

n = 3

3.5. Lipid profile Analysis

Table 6 shows the effect of ethanol extract of *Tetrapleura tetraptera* fruit on lipid profile of CCl_4-intoxicated rats. At the administration of CCl_4, there was a significant ($p<0.05$) increase in the concentration of Total cholesterol (TC), Triacylglycerol (TAC), Low Density Lipoprotein (LDL-C) and significant ($p<0.05$) decrease in HDL-C as seen in (CCl_4 administered group) when compared to that of the normal control group. Groups that were treated with extract (group 3 - 5) showed a significant ($p<0.05$) reduction in TC, TAG, LDL and significant ($p<0.05$) increase in HDL-C when compared to that of the untreated group (group 2). Oral administration of the standard drug (silymarin, 100 mg/kg) significantly ($p<0.05$) decreased the levels of TC, TAG, LDL-C and significantly ($p<0.05$) increased the HDL-C. These values were comparable to that of the normal control group.

Table 6 Effect of ethanol extract of ***Tetrapleura tetraptera*** fruit on Lipid Profile of CCl_4-Intoxicated Rats

Treatment Group	TC (mg/dl)	TAG (mg/dl)	LDL (mg/dl)	HDL (mg/dl)
Group 1	4.86 ± 0.09	0.98 ± 0.10	2.98 ± 0.15	2.40 ± 0.04
Group 2	6.85 ± 0.05	1.30 ± 0.06	6.16 ± 0.06	1.12 ± 0.06
Group 3	4.10 ± 0.07	0.79 ± 0.03	2.56 ± 0.04	2.58 ± 0.05
Group 4	4.69 ± 0.10	0.90 ± 0.03	3.40 ± 0.05	2.17 ± 0.11
Group 5	4.56 ± 0.06	0.86 ±0.07	3.15 ± 0.06	2.13 ± 0.04
Group 6	4.64 ± 0.11	0.76 ± 0.03	2.08 ± 0.03	2.47 ± 0.07

(Results are expressed as Means ± SD; n=5); Mean values down the column are significantly different from each other at P<0.05.

3.6. Malondialdehyde

Table 7 shows that the concentrations of serum MDA significantly increased (P<0.05) in the CCl_4 untreated group as compared to that of normal control group. The elevated level of serum MDA was significantly decreased (P<0.05) by the treatment of rats with 100, 300 and 500 mg/kg of ethanol extract of *Tetrapleura tetraptera* fruit as compared to the CCl_4 administered group. In this study, the standard drug (silymarin, 100 mg/kg) produced a significant reduction (P<0.05) in MDA concentrations when compared to untreated group. This is comparable to the normal control group.

Table 7 Effect of ethanol extract of ***Tetrapleura tetraptera*** fruit on Malondialdehyde (MDA) concentrations of CCl_4-intoxicated Rats

Treatment Group	Malondialdehyde (MDA) (mg/dl)
Group 1	3.17 ± 0.14
Group 2	4.48 ± 0.24
Group 3	3.19 ± 0.12
Group 4	3.45 ± 0.21
Group 5	3.44 ± 0.22
Group 6	3.34 ± 0.17

(Results are expressed as Means ± SD; n = 5); Mean values down the column are significantly different from each other at P<0.05.

4. Discussion

Phytochemical evaluation is one of the excellent tools for the quality assessment of medicinal plants. The phytochemical screening of ethanol extract of *Tetrapleura tetraptera* fruit showed that that they contain relative amount of flavonoids, glycosides, phenolics, saponins, tannins, terpenoids, alkaloids, amino acids, steroids and coumarins. Glycosides, flavonoids and phenolics were detected in very small concentration. alkaloids, coumarins and amino acids were found in moderate amounts while saponins, tannins, steroids and terpenoids were detected in very high amount in the extract. The phytochemical compounds detected have been reported to have medicinal importance and pharmacological therapy. This findings is in tandem with the works of Nwafor et al., 2024 whose phytochemical screening of *Tetrapleura tetraptera* fruit extract detected the presence of tannins, phenolic compounds, saponins, alkaloids, steroids, glycosides, terpenoids, flavonoids, amino acids and coumarins. This is consistence with the report of Nwoba et al., 2015 who documented that the phytochemical screening of the pulp of the *Tetrapleura tetraptera* fruit contains tannins, phenolic compounds, saponins, alkaloids, steroids, glycosides, resins, terpenoids and flavonoids. However, their report did not detect amino acids and coumarins. Larbie et al., 2020, whose findings were in close agreement with this study revealed that it contains tannins, terpenoids, reducing sugars, sterols, coumarins, saponins, alkaloids, flavonoids but amino acids and phenolic compounds were not detected. Enema et al., 2019 findings is at par with this study whose phytochemical screening of fractions of *Tetrapleura tetraptera* leaves revealed phenols, alkaloids, terpenoids, tannins, flavonoids and saponins. However, their reports contrast in glycosides, coumarins, steroids, and amino acids which were not detected in the ethanol extract of *Tetrapleura tetraptera* fruit.

Lipid peroxidation is the process under which oxidants such as free radicals or nonradical species attack lipids containing carbon-carbon double bonds, especially polyunsaturated fatty acids (PUFAs) that involve hydrogen abstraction from a carbon, with oxygen insertion resulting in lipid peroxyl radicals and hydroperoxides. The degree of lipid peroxidation can be estimated by the amount of malondialdehyde in tissues. In the present study, *Tetrapleura tetraptera* fruit extracts showed a higher inhibition of the lipid peroxidation which characterized a decrease of the level of MDA. These protective effects of the lipid peroxidation varied depending on the part of the plants, the solvent used for its extraction, and the quality and the quantity of phytochemical compounds found in the extract. A decrease in lipid peroxidation may lead to a reduction in the arterial wall cholesterol content. Elevated levels of serum MDA induced by CCl_4 represent a predictor of atherosclerosis, hepatocellular damage, failure of natural antioxidant defense system to prevent overproduction of free radicals and other pathological diseases. MDA may modulate some cell functions, including cell proliferation, and it can react with DNA bases forming adducts, which could be mutagenic; therefore, contributing to the cancer development (Zapata – Londono *et al*., 2020). Phytochemicals contribute strongly to the protective activities of the cell. Flavonoids are naturally occurring antioxidants that inhibit lipid peroxidation in biological membranes. Hypolipidemic activity of flavonoids from various sources has been reported by several workers (Adaramoye et al., 2005; Chan et al., 1999).

Lipid peroxidation is considered to be a primary mechanism of cell membrane destruction by free radicals because MDA conjugates with amino group of proteins to form intra- and inter-molecular cross-links that inactivate the membrane-bound enzymes and receptors. Onda et al., 2017 findings are in support of this study who reported significant (P<0.05) decrease of Malondialdehyde (MDA) at the administration of *Tetrapleura tetraptera* Taub fruit extract in Carrageenan/Kaolin –induced acute monoarthritis in rats. The work of Famobuwa et al., 2015 is in support of this findings who reported that MDA significantly decreased at the administration of the fruit and stem bark of *Tetrapleura tetraptera* extract on albino rats. Atawodi et al., 2014 obtained similar results who documented that the administration of methanolic extract of *Tetrapleura tetraptera* leaves significantly (P<0.05) reduced the level of MDA in diabetic rats. This strongly suggests the ability of the plant and its constituents to prevent oxidative damage, probably by interfering with the free radical-induced processes, leading to intra- and inter-molecular cross-linkages. Nwozo and Orojobi (2010) findings is in agreement with this study who demonstrated that the administration of *Tetrapleura tetraptera* fruits and seeds significantly (P<0.05) decrease lipid peroxidation than Questran in cholesterol fed rats.

This study revealed that all CCl_4 – intoxicated rats displayed hyperlipidemia as shown by their elevated levels of serum Total Cholesterol (TC), Triacylglycerols (TAG), Low Density Lipoproteins (LDL) and reduction in High Density Lipoproteins (HDL) level. The elevation of serum total cholesterol and low-density lipoprotein (LDL) cholesterol has been implicated as a primary risk factor for cardiovascular disease, atherosclerosis, coronary artery disease and peripheral vascular diseases. Groups that were treated with extract (group 3 - 5) including the standard drug showed a significant ($p<0.05$) reduction in TC, TAG, LDL and significant ($p<0.05$) increase in HDL-C when compared to that of the untreated group (group 2). The mechanism of hypolipidemic activities may be due to inhibition of the absorption of dietary cholesterol in the intestine, stimulation of the biliary secretion of cholesterol and cholesterol excretion in the faeces. Nwozo and Orojobi 2010 is in tandem with this study who reported that the crude methanol extract of *Tetrapleura tetraptera* fruit and the seeds were found to be highly effective in reducing the levels of serum and hepatic total cholesterol, triacylglycerol and low-density lipoprotein in the studied animals.

5. Conclusion

An overabundance of free radicals in the cell leads to uncontrolled chain reactions and lipid peroxidation, ensuing in diverse pathological situations which can encompass atherogenesis and most cancers. The ensuing oxidative stress will affect the functional and structural integrity of membrane bound enzymes. Ethanol extract of *Tetrapleura tetraptera* fruit extract was able to restore the damages done to the membranes. The most efficacious dose of the crude extract of *Tetrapleura tetraptera* fruit was 100 mg/kg body weight of *Tetrapleura tetraptera* fruit extract. It possessed the best hypolipidemic effects and lipid peroxidation inhibitory activities. This may be attributed to the presence of flavonoids, phenolics, and coumarins and others in the plant extract. Evidence from the present study indicates that the crude extract has hypolipidemic, and lipid peroxidation inhibitory activities. Consequently, *Tetrapleura tetraptera* fruit should be deployed for therapeutic promise in preventing cardiovascular diseases, overweight, obesity and hyperlipidemia including cell and tissue intoxication.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

The Department of Biochemistry, Madonna University, Nigeria, Elele, Rivers State approved the use of animals for this research study. All the experiments has been examined and approved by the approprioate ethics committee.

Authors' Contributions

This work was carried out in collaboration among all authors. Authors MNN and CEP designed the study, wrote the protocol and supervised the work. Authors CGI, NFG and AJW performed the statistical analysis. Authors MOE and CSO managed the analyses of the study. Author MNN wrote the first draft of the manuscript, managed the literature searches and edited the manuscript. All authors read and approved the final manuscript.

References

[1] Boutari, C, Karagiannis, A, Athyros, VG. Rosuvastatin and ezetimibe for the treatment of dyslipidemia and hypercholesterolemia. Expert Rev. Cardiovasc. Ther. 2021; 19: 575–580.

[2] Kemigisha E, Owusu E, Elusiyan CA, Omujai F. Tweheyo M. *Tetrapleura tetraptera* in Ghana, Nigeria, and Uganda: household use and local market, forests, trees and livelihoods. 2018; 27: 243 – 256.

[3] Feldman, F, Koudoufio, M, Desjardins, Y, Spahis, S, Delvin, E, Levy, E. Efficacy of Polyphenols in the Management of Dyslipidemia: A Focus on Clinical Studies. Nutrients, 2021, 13: 672.

[4] Boden, WE, Bhatt, DL, Toth, PP, Ray, KK, Chapman, MJ, Luscher, TF. Profound reductions in first and total cardiovascular events with icosapent ethyl in the REDUCE-IT trial: Why these results usher in a new era in dyslipidaemia therapeutics. European Heart Journal, 2020; 41:2304.

[5] Abbas, M, Saeed, F, Anjum, FM. Afzaal, M, Tufail, T,Bashir, MS, Ishtiaq, A, Hussain, S, Suleria, HAR. Natural polyphenols: An overview. Int. J. Food Prop. 2017; 20: 1689–1699.

[6] Gong, X, Li,X, Xia, Y,Xu, JF,Li, QY,Zhang, CH, Li, MH. Effects of phytochemicals from plant-based functional foods on hyperlipidemia and their underpinning mechanisms. Trends Food Science and Technology, 2020; 103: 304–320.

[7] Zhang, QJ, Dong, JL, Yu, Z. Pleiotropic use of statins as non-lipid-lowering drugs. International Journal of Biological Science, 2020; 16: 2704–2711.

[8] Mach, F, Baigent, C, Catapano, AL, Koskina, KC, Casula, M, Badimon, L, Chapman, MJ, De Backer, GG, Delgado, V, Ference, BA. 2019 ESC/EAS guidelines for the management of dyslipidaemias: Lipid modification to reduce cardiovascular risk. Atherosclerosis, 2019; 290: 140–205.

[9] Fernandez-Friera, L, Penalvo, JL, Fernandez-Ortiz, A, Ibanez, B, Lopez-Melgar, B,Laclaustra, M, Oliva, B, Mocoroa, A, Mendiguren, J, De Vega, VM. Prevalence, vascular distribution, and multiterritorial extent of subclinical atherosclerosis in a middle-aged cohort the PESA (Progression of Early Subclinical Atherosclerosis) Study. Circulation, 2015; 131: 2104–2113.

[10] Toori, M. A., Joodi, B. Sadeghi, H. and Sadeghi, H.. Hepatoprotective activity of aerial parts of *Otostegia persica* against carbon tetrachloride – induced liver damage in rats. Avicenna Journal of Phytomedicine, 2015; 5(3): 238 – 246.

[11] Erukainure OL, Onifade, OF, Odjobo BO, Olasehinde, TA, Adesioye, TA,Tugbobo-Amisu, A., Adenekan, SO and Okoronkwo GI. Ethanol extract of *Tetrapleura tetraptera* fruit peels: Chemical characterization, and antioxidant

potentials against free radicals and lipid peroxidation in hepatic tissues. Journal of Talibah University for Science, 2017; (3): 1-7.

[12] Saliu IO, Bhagat, R, Ojo, OB, Aknmoladun, AO, Olaleye MT, Seth, P. Rema V. Reduction of anoxia-induced bioenergetic disturbance in astrocytes by methanol fruit extract of *Tetrapleura tetraptera* and in silico evaluation of the effect of its antioxidative constituents on excitotoxicity. 2021; 8: 264 – 276.

[13] Moukette MB, Pieme, AC, Nyabiapa PC, and Ngogang JY. *In vitro* ion chelating, antioxidative mechanism of extracts from fruits and barks of *Tetrapleura tetraptera* and their protective effects against Fenton mediated toxicity of metal ions on liver homogenates. Evidence Based Complement Alternative Medicine, 2015; 10: 1155.

[14] Irondi EA, Oboh G, Agboola SO, Boligon AA, Athayde ML. Phenolics extract of *Tetrapleura tetraptera* fruit inhibits xanthine oxidase and Fe2+-induced lipid peroxidation in the kidney, liver, and lungs: Tissues of rats in vitro. Food Science and Human Wellness, 2015; 70: 1-7.

[15] Ogunlakin AD, Sonibare MA. Antioxidant and antidiabetic properties of *Tetrapleura tetraptera* Taub whole fruit. Journal of Phytomedicine and Therapeutics, 2024; 23(1): 1150-1170.

[16] Soumen, B. Membrane lipid peroxidation and its conflict of interest: The two faces of oxidative stress. Current Science, 2014; 107(11):10.

[17] Zarezade, V, Moludi, J, Mostafazadeh, M, Mohammadi, M. and Veisi, A. Antioxidant and hepatoprotective effects of *Artemisia dracunculus* against CCl4 – induced hepatotoxicity in rats. Avicenna Journal of Phytomedicine, 2018; 8(1): 51 - 62.

[18] Wang, FS, Fan, JG, Zhang, Z, Gao, B and Wang, HY. The global burden of liver disease: The major impact of China. Hepatology, 2014; 60(6): 2099-2108.

[19] Brai, BI, Adisa, RA and Odetola, AA. Hepatoprotective properties of aqueous leaf extract of *Persea Americana*, Mill (Lauraceae). 'Avocado' against CCl_4 –Induced damage in rats. African Journal, Complementary and alternative Medicines, 2014; 11(2): 237 – 244.

[20] Ugwah-Oguejiofor, CJ and Ugwah, OM. Hepatoprotective activity of the aerial parts of *Carallum adalzielii* against carbon tetrachloride-induced hepatotoxicity in rats. Ife Journal of Sciences, 2018; 20(1): 169-179.

[21] Ojewole JA, Adewunmi CO. Anti-inflammatory and hypoglycemic effects of *Tetrapleura tetraptera* (Taub) Fabaceae fruits aqueous extract in rats. Journal of Ethnopharmacology, 2007; 95: (2-3): 177 - 182.

[22] Famobuwa OE, Lajide L, Owolabi BJ, Osho IB, Amubo UE. Antioxidant activity of the fruit and stem bark of *Tetrapleura tetraptera* Taub (Mimosaceae). BJPR, 2016; 9(3): 1 – 4.

[23] Adusei S, Otchere JK, Oteng P, Mensah RQ. Phytochemical analysis, antioxidant and metal chelating capacity of *Tetrapleura tetraptera*. Heliyon, 2019; 5(11): 02762.

[24] Mbaveng AT, Chi GF, Bonsou IN, Ombito JO, Yeboah SO, Kuete V, Efferth T. Cytotoxic phytochemicals from the crude extract of *Tetrapleura tetraptera* fruits towards multifactorial drug resistant cancer cells. Journal of Ethnopharmacology, 2021; 267: 113632.

[25] Korang J, Pentsils S, Adomako J. Natural fungicide from prekese. PACN Congress: Sustainable Agriculture, 2017; 30.

[26] Ajayi BO, Fajemilehin AS, Dada CA, Awolusi OM. Effect of *Tetrapleura tetraptera* fruit on plasma lipid profile and enzyme activities in some tissues of Hypercholesterolemic rats. Journal of Natural Products and plant Resources, 2011; 1(4): 47 – 55.

[27] Tsala DE, Habtemariam S, Simplice FH, Thierry BNM, Abraham JA, Thiophile D. Topically applied Tetrapleuratetraptera stem bark extract promotes healing of excision and incision wounds in rats. Journal of IntercultEthnopharmacology, 2014; 3(2): 63-67.

[28] Noamesi BK, Mensah M, Bogale E, Dagney E and Adotey J. Antiulcerative properties and acute toxicity profile of some African medicinal plants extracts. Journal of Ethnopharmacology, 1994; 18: 103-107.

[29] Lin l, Agyemang K, Abdelsamie MAS, Cut H. Anti-bacterial mechanism of *Tetrapleura tetraptera* extract against Escherichia coli and staphylococcus aureus and its application in pork. Journal of Food Safety, 2019; 39(6): 12693.

[30] A.O.A.C. Association of Official Analytical Chemists, Official Methods of Analysis of the A.O.A.C., International, 18th ed. Association of Official Analytical Chemists, Gathersburg, MD, 2005.

[31] James, GS.. In Encyclopedia of Analytical Science, 2019; (Third Edition)

[32] Odebiyi, O. O. and Sofowora, E. A. Phytochemical screening of Nigerian medicinal plants, Part III. LIoydia, 1978; 41(3): 234 – 246.

[33] Abell, LL., Levy, BB., Brodie, BB. and Kendall, EF. A simplified method for the estimation of total cholesterol in serum and demonstration of its specificity. Journal of Biological Chemistry, 1952; 195(1): 357 – 366.

[34] Friedewald, WT, Levy, RI and Fredrickson, DS. Estimation of the concentration of low-density Lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. Clinical Chemistry, 1972; 18: 499 – 502.

[35] Toth, LS. and Cicchetti, D. A developmental psychopathology perspective on child maltreatment. Social and emotional development , 2013; (Vol 3, 7th eds.) New York, NY: John Wiley.

[36] Otvos, J. Supplement: Triglycerides as a risk factor in cardiac heart disease. Clinical cardiology, 1999; 22(2): 11 – 27.

[37] Wallin, B., Rosengren, B., Shetzer, H. G., and Camejo, G. Lipoprotein oxidation and measuring of thiobarbituric acid and reacting substances (TBARS) formation in a single microlitre plate: Its use for evaluation of antioxidants. Annual Journal of Biochemistry, 1993; 208(1): 10 – 15.

[38] Nwafor MN, Amadi EB, Whyte AJ, Godwin NF, Abosede UO, Ogunwa CS, Eji MO, Babandi A. Comprehensive Phytochemical and Antioxidant Profiling of *Tetrapleura tetraptera* Fruit: A Nutritional and Bioactive Potential Assessment from Rivers State, Nigeria. Asian Journal of Biochemistry, Genetics and Molecular Biology, 2024; 16(12):88-99. Available from: https://journalajbgmb.com/index.php/AJBGMB/article/view/425

[39] Nwoba EG. Proximate and Phytochemical composition of the pulp of *Tetrapleura tetraptera* fruits consumed in Abakiliki, Nigeria. International Journal of Engineering Research and Technology (IJERT), 2015; 4(6): 1286 – 1294.

[40] Larbie C, Robertson FCM, Quaocoe EB, Opoku R, Kabiri NC. *Tetrapleura tetraptera* of Ghanaian origin: Phytochemistry, antioxidant and antimicrobial activity of extracts of plant parts. Journal of Pharmaceutical Research International, 2020; 32: 78 – 96.

[41] Enema OJ, Umoh UF, Thomas PS, Adesina Sk, Eseyin OA. Phytochemical and antioxidant studies of leaf of *Tetrapleura tetraptera* Taubert (Mimosaceae). CERN European Organisation for Nuclear Research, 2019; Zenodo.

[42] Zapata – Londono, M. B., Polo, R. A., Alzate – Arbelaez, A. F., Restrepo – Betancur, F. L., Rojano, B. A. and Maldonado – Celis, M. E. Effect of mango (*Mangifera indica*) cv. Azucar juice consumption on plasma antioxidant capacity and oxidative stress biomarkers. Vitae, 2020; 27(1): 2145 – 2660.

[43] Adaramoye OA, Nwaneri VO, Anyanwu KC, Farombi EO, Emerole GO. Possible anti-atherogenic effects of kolaviron (a Garcinia kola seed extract) in hypercholesterolemic rats. Clinical Experimental Pharmacology and Physiology, 2005; 32: 40-46.

[44] Chan PT, Fong WP, Cheung YL, Huang Y, Ho WK, Chen Z. Jasmine green tea epicatechins are hypolipidemic in hamsters (Mesocricetus auratus) fed a high fat diet. Journal of Nutrition, 1999; 1094-1101.

[45] Onda, EE, Sonibare MA, Ajayi AM, Umukoro, S. Anti-inflammatory and antioxidant effects of *Tetrapleura tetraptera* Taub fruit extract in carrageenan/kaolin – induced acute monoarthritis in rats. Nigeria Journal of Pharmaceutical Resource, 2017; 13(2): 157 – 166.

[46] Famobuwa OE, Lajide L, Owolabi BJ, Osho IB, Amuho UE. Antioxidant Activity of the Fruit and Stem Bark of *Tetrapleura tetraptera* Taub (Mimosaceae). J. Pharm. Res. Int., 2015; 9(3):1-4. Available from: https://journaljpri.com/index.php/JPRI/article/view/472

[47] Atawodi SE, Yakubu OE, Liman ML, Iliemene DU. Effect of methanolic extract of *Tetrapleura tetraptera* Taub leaves on hyperglycemia and indices of diabetic complications in alloxan –induced diabetic rats . Asian Pacific Journal of Tropical Biomedicine, 2014; 4(4): 272-278.

[48] Nwozo OS, Orojobi FB. Hypolipidemic and antioxidant effects of *Tetrapleura tetraptera* fruits including seeds in hypercholesterolaemic rats. Seed Science and Biotechnology, 2010; 4(1): 73-78.