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Research Article

Phytochemical, GC-MS, FTIR and Amino acid profile of methanol extract of *Tetrapleura tetraptera* fruit

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Abstract

The methanolic fruit extract of *Tetrapleura tetraptera* was analyzed for the presence of phytocompounds, their bioactivity, the functional groups involved in this activity, and its amino acid profile using standard procedures. Phytochemicals such as tannins, phenols, flavonoids, and alkaloids were identified as being highly present. Gas chromatographic-mass spectrometric (GC-MS) analysis identified 16 bioactive compounds, with 2-thiopheneethanol (58.77%) being the most abundant. Curcumin, with the most diverse pharmacological role, and other bioactive compounds such as cedren-13-ol, 8 (1.56%), N-benzyl stearamide (4.46%), a prominent fatty acid amide hydrolase (FAAH) inhibitor; pthalic acid, butyl undecyl ester (1.49%); and phenol, 2, 6-bis (1,1 dimethyl ethyl) (1.46%), were also present. Fourier transform infrared (FTIR) analysis confirmed the presence of alkanes, esters, benzene rings, aliphatic, sulfonic acid, and methylene chains. Also, the amino acid analysis of the *T. tetraptera* revealed that the fruit contains 18 amino acids. Leucine (4.20%), phenylalanine (3.37%), and valine (3.25%) were the most abundant essential amino acids identified, with glutamic (7.20%) and aspartic acid (5.61%) having the highest concentrations as non-essential amino acids. This therefore indicates that *T. tetraptera* fruit could be used as a pharmacological or therapeutic agent as well as a dietary condiment, particularly at this time when there is a demand for novel protein sources.

Keywords: *Tetrapleura tetraptera*, phytochemicals, GC-MS, FTIR, amino acid, curcumin

INTRODUCTION

Humans have been using medicinal plants and extracts for the treatment of ailments for millennia. These plants produce a variety of antimalarial, antihypertensive, antitussive, and analgesic medicines[1]. These medicinal plants serve as key leads for drug development for a variety of pharmacological targets, including cancer, malaria, cardiovascular illness, and neurological disorders. Medicinal plants are plant parts or the entire plant that have curative characteristics. Unlike traditional (synthetic) pharmaceuticals, which can have negative side effects, medicinal formulations using plants are far less expensive and safer to use[2]. They contain bioactive compounds and extracts that have enormous potential for developing new and innovative products for disease prevention and treatment. These bioactive components such as saponins, tannins, flavonoids, alkaloids, phenols, phytates, oxalates, steroids, cyanogenic glycosides, and essential oil can be used as medicinal agents, models for new synthetic compounds, and taxonomic markers for novel compound identification [3].

Gas chromatography-mass spectrometry (GC-MS) is a quick and accurate approach for examining the constituents in complicated mixtures [4]. It enables the identification of several chemicals in modest amounts of plant materials. It provides the structure and weight of phytocompounds present in a plant sample. The only disadvantage is that it does not detect high boiling point compounds, which are difficult to volatilize[5]. The Fourier transform infrared spectrometer (FTIR) is one of the most powerful tools used in identifying the functional groups (based on the chemical bonds) present in organic compounds. The FTIR spectra show the wavelength of the light absorbed, which is characteristic of the chemical bonds in the phytocompound.

Proteins are essential for the repair, growth, and development of cells, as they constitute a significant portion of the protoplasm. Amino acids are the fundamental components of proteins. They function as metabolic intermediates to preserve health and vitality. These amino acids are divided into two major categories: essential (which the body cannot produce) and non-essential (which can be synthesized by the body). The essential amino acids are obtained from food, and their deficiency can lead to the breakdown of muscle tissue[6]. This is particularly important as the rising cost of conventional protein sources in third-world countries increases the demand for novel protein sources[7].

Tetrapleura tetraptera is a deciduous tree with a single stem that belongs to the Fabaceae family. It grows to heights of up to 25m and girths of 1.2-3 meters. It is found in countries of Central and West African rainforests like Congo, Uganda, Nigeria, Ghana, Mali, Burkina Faso, and Mauritania. In Nigeria, the tree known as Aridan in English is called *Osakirisa or Oshosho* in Igbo, *Dawo* in Hausa, and *Aridan* in Yoruba[8]. Different portions of the plant have different mineral profiles and are high in protein, beta-carotene, amino acids, fatty acids, and various phenolics and flavonoids[9]. Various parts of the plant such as leaves, stem-bark, roots, fruits, and seeds are

used locally to treat ill health such as ulcers, general body pains, weakness, malaria and fever, wounds, burns, skin disorders, snake bites, convulsion, epilepsy, measles, anti-natal and post-natal anemia, cancers of the breast and uterus, etc[10]. Flowers and fruits of the plant are frequently used to manufacture fragrances in the cosmetics industry. *T. tetraptera* fruits are also extensively utilized in traditional cookery in Nigeria, Ghana, and Cameroon as a favorite flavoring spice[11]. The fleshy pulp has a very strong fragrant odor that aids in insect repellant and flavoring properties[12].To better understand the use of this fruit as a therapeutic agents as well as a potential source of protein, the phytocompounds, their bioactivity, the functional groups involved in this activity and the amino acid profile of *T. tetrapleura* methanol fruit extract was examined.

MATERIALS AND METHODS

Plant material

Tetrapleura tetraptera fruit was bought at the popular Relief market in Owerri Municipal Local Government Area of Imo state. The plant was identified by a plant taxonomist in the Department of Wildlife and Forestry, Federal University of Technology Owerri (FUTO), Imo state.

Preparation of extract for phytochemical analysis

The dried pods were washed under running water and allowed to dry for a day. They were then pounded into a coarse powder with a mortar and pestle. 250 g of coarsely powdered whole fruit were maintained in contact with 1 L of methanol in a sealed container using the cold maceration process for the methanol extraction[13]. For 72 hours, it was regularly agitated at room temperature until the soluble ingredient was entirely dissolved. After that, the mixture was strained and filtered using Whatman No. 1 filter paper (125 mm). The methanol extract was then concentrated with the use of a rotary evaporator (78^{o}C) to one-quarter of its original volume.

Qualitative Phytochemical assay

The methanolic extracts of the whole fruit of *Tetrapluera tetraptera* were used to screen for the presence of flavonoids, alkaloids, terpenoids, tannins, steroids, saponins, phenols, glycosides and reducing sugars.

Tannin test

1 g of methanolic extract of *T. tetraptera* was heated for 5 minutes in 10 ml of 45% ethanol. After filtering, three drops of ferric chloride ($FeCl_3$) were added to one milliliter of filtrate. The color change from blue-black to brownish blue was a positive indication of tannins[14].

Alkaloid (General) test

0.5g of the methanolic extract of the sample was dissolved in 5 ml of dilute hydrochloric acid and filtered. 1ml of Mayer's reagent was added to 1ml of the filtrate in the first test tube while Wagner's reagent was added to 1ml of the filtrate in a second test tube. A creamy white and reddish-brown precipitate in the first and second test tubes showed the presence of alkaloids.

Saponin test

1 gram of the extract was warmed in 10 milliliters of distilled water for 1 minute. 1 ml was put in a test tube, followed by 4 milliliters of water, and thoroughly shaken for 5 minutes. Persistent foam or bubbles that formed for more than one minute showed that saponin was present[15].

Flavonoid test

15 ml of ethyl acetate was combined with 1 gram of the extract and boil for 3 minutes. The mixture described above was filtered. 500µl of 1% ammonium chloride (AlCl3) and 500µl of aqueous ammonia (NH_3aq) were added to 2 milliliters of the filtrate. The presence of flavonoids in the methanol extract was indicated by a darker yellowish color at the upper layer and a clear yellow color beneath it[14].

Terpenoids test

A reddish-brown precipitate formed after adding 0.5 milliliters of chloroform and 1 milliliter of concentrated H_2SO_4 to 0.1 g of the sample's methanol extract, showed that terpenoids were present[15].

Steroids test

2 milliliters of acetic anhydride and 3 milliliters of conc. H_2SO_4 were combined with 0.5 g of the sample's methanol extract in a test tube, and the formation of a green or violet color showed that steroids were present[14].

Phenols test

The presence of phenols in the extract was demonstrated by the formation of a bluish color when 2 milliliters of 5% aq. $FeCl_3$ was added to 0.2 g of the methanol extract[14].

Glycosides' (Fehling's) test

To 1 gram of extract, 10 milliliters of water were added and boiled for 5 minutes. 2 ml of dilute aqueous ammonia was added to 2 ml of the filtrate. Then 400 milliliters of Fehling solutions A (aqueous $CuSO_4$ solution) and B (potassium tartrate solution) were added and boiled for 5 to 10 minutes. The brick red coloration indicated that glycosides were present.

Reducing sugar test

1 gram of the methanolic extract was boiled in 10 milliliters of water for 10 minutes. 1 milliliter of the filtrate was boiled for 5 minutes with 200 milliliters of Fehling solution A (an aqueous solution of $CuSO_4$) and 200 milliliters of Fehling solution B (potassium tartrate). The presence of reducing sugar in the methanol extract was indicated by a change in color to a brick-red precipitate.

GC-MS ANALYSIS

The GC-MS analysis of *Tetrapleura tetraptera* was carried out by soaking the 10g of the methanol extract in 30ml in methanol overnight and then strained with 2g of sodium sulphate through ashless filter paper. By releasing nitrogen into the solution, the extract was concentrated to 1ml. For the analysis, 2ul of the methanol extract of the plant part was introduced onto the GC column. The DB-5ms capillary column (30m0.25mm; film thickness 0.25m) is used in the GC (Agilent 6890N) and MS (5975B MSD). The starting temperature was at 40 degree Celsius and gradually escalated to 150 degree Celsius at a pace of 100 degree Celsius per minute. At a rate of 5 degree Celsius per minute, the temperature was gradually increased to 230 degree Celsius. The operation was repeated until the temperature reached 280 degree Celsius at a rate of 20 degree Celsius per minute, which was kept for 8 minutes. The temperature of the injector port stayed constant at 280 degree Celsius, whereas the temperature of the detector was 250 degree Celsius at the time. With a rate of flow of 1ml/min, helium which was the carrier gas was employed. The split ratio was 110.1eV while the ionization voltage was 70eV.

Identification of Unknown Components in the methanol extract

The phytochemicals were then identified by comparing the unknown GC-MS peak value and chromatogram to a known chromatogram and peak value from the National Institute of Science and Technology 2014 to determine the unknown component in the extract. Information on the molecular formula, molecular weight, retention duration, and percentage content was acquired with that.

FOURIER- TRANSFORM INFRARED SPECTROSCOPIC (FT-IR) ANALYSIS

The *T. tetraptera* sample was ground in a mortar in order to reduce the particle size to between 1- 2 microns. About 0.1 mg of finely powdered sample was made to combine with powdered potassium bromide. The mixture was then applied to the surface of the potassium bromide plate, after which the second window was positioned on top. For even distribution of the mixture between the plates, the two windows were made to rub on each other using a back and forth circular motion. A proper preparation ensured that the mixture appeared slightly translucent. A spectrum was obtained after placing the sandwiched plates in the spectrophotometer. The Fourier-Transform Infrared Spectrum was captured using the potassium bromide pellet technique, where wavelength range of 400-4000cm-1 with a resolution of 4cm-1 and a scanning speed of 2mm/sec. was captured on a Bruker Tensor 27 Spectrophotometer.

AMINO ACID DETERMINATION

T. tetraptera's amino acid profile was determined using methods described by Adeyeye and Afolabi[16]. The fruit was initially dried to a constant weight at 70 degrees Celsius. Then, 4 g of sample mass was defatted in a 2:1 mixture of chloroform and methanol. It was extracted using a Sohlex extraction apparatus for 15 hours.

Acid hydrolysis: In a glass ampoule, 1.639 g of the defatted sample was weighed. Nitrogen was introduced into the ampoule after 6N of hydrochloric acid (HCl) was added in order to remove oxygen. The glass ampoule was then sealed and put in the oven for 22 hours at 105 ± 5 degrees Celsius. After the ampoule cooled, the tip was broken and the contents were filtered to remove the humins. Afterward, the filtrate was evaporated to dryness using a rotary evaporator. The residue was dissolved in 5 milliliters of acetate buffer and stored in a freezer in a plastic specimen bottle.

Alkaline hydrolysis of the sample for determination of tryptophan: Alkaline hydrolysis results in the recovery of Tryptophan, which is chemically decomposed by acid hydrolysis. After defatting approximately 2 g of dried *T. tetraptera* in chloroform/methanol (2:1) for 15 hours, hydrolysis was performed using 10 ml of 4.2 M sodium hydroxide (NaOH) at 105 ± 5 degree Celsius for 4 hours [17]. After breaking the ampoule, the obtained filtrate was neutralized to a pH of 7.00 and evaporated to dryness at 40 degrees Celsius with the use of a rotary evaporator. The residue which was obtained was then dissolved in 5 ml of pH 9.0 borate buffer and stored in the freezer.

Hydrolysate injection into the analyzer: In order to separate and analyze the hydrolyzate, 60 microliters of the substance were dispensed into the cartridge of the Applied Biosystems PTH Amino Acid Analyzer.

Method for calculating amino acids values: Attached to the analyzer is an integrator that calculates the peak area proportional to each amino acid.

RESULTS

Table 1: Phytochemical constituents of methanol extract of *Tetrapleura tetraptera* fruit

S/No	Phytochemical	*T. tetraptera* methanol extract
1	Saponin	+
2	Tannin	++
3	Phenol	++
4	Glycosides	+
5	Reducing sugar	++
6	Alkaloids	++
7	Flavonoids	++
8	Terpenoids	++
9	Steriods	+

++ indicates highly present while + indicates slightly present

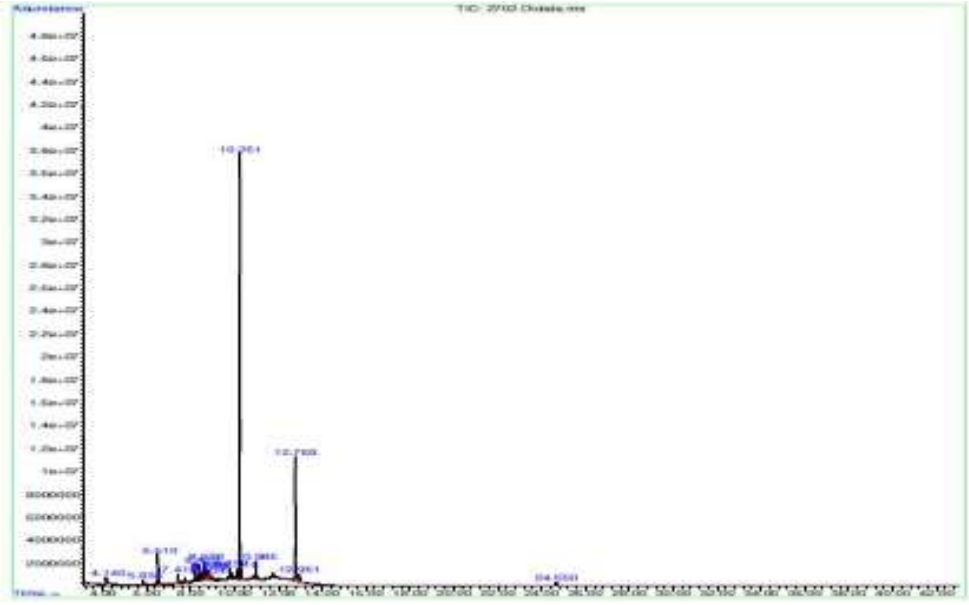
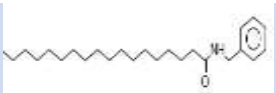
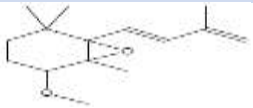
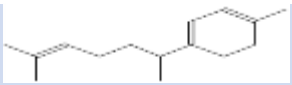
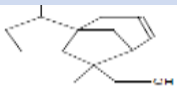


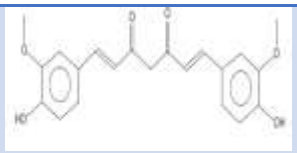
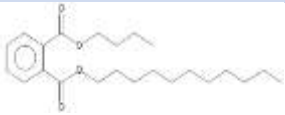
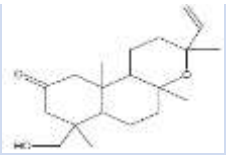
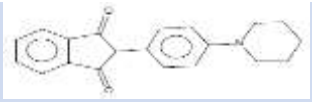
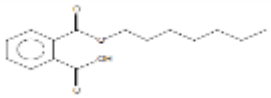
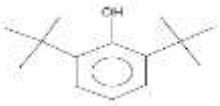
Fig 1: GC-MS chromatogram of the methanol extract of *T.tetraptera* fruit

Table 2: Phytocompounds Identified in the Methanolic extract of *Tetrapleura tetraptera* by GC-MS

No	Retention Time (min)	Compound name	Molecular formula	Peak Area %
1	4.140	Cyclobut-1-enylmethanol	C_5H_8O	2.391
2	5.834	1-Butoxy-1-isobutoxy-butane	$C_{12}H_{26}O_2$	0.903
3	6.510	N-Benzylstearamide	$C_{25}H_{43}NO$	4.457
4	7.416	5-Methoxy-2,2,6-trimethyl-1-(3-methyl-buta-1,3-dienyl)-7-oxa-bicyclo[4.1.0]heptanes	$C_{15}H_{24}O_2$	1.355
5	8.422	Tridecane, 2-methyl-2-phenyl-	$C_{20}H_{34}$	2.402
6	8.628	10,13-Octadecadiynoic acid, methyl ester	$C_{19}H_{30}O_2$	2.491
7	8.704	1-Methyl-4-(6-methylhept-5-en-2-yl)cyclohexa-1,3-diene	$C_{15}H_{24}$	0.791
8	8.763	Cedren-13-ol, 8-	$C_{15}H_{24}O$	1.556
9	8.810	Curcumin	$C_{21}H_{20}O_6$	1.057
10	9.757	Pthalic acid, butyl undecyl ester	$C_{23}H_{36}O_4$	1.490
11	10.116	9H-Naphtho[2,1-b]pyran-9-one, 3-thenyldodecahydro-7-(hydroxymethyl)-3,4a,7,10a-tetramethyl-, [3R-(3α,4αβ,6aα,7α,10αβ,10bα)]	$C_{20}H_{32}O_3$	1.235
12	10.251	2-Thiopheneethanol	C_6H_8OS	58.771
13	10.986	2-(4-Piperidin-1-yl-phenyl)-indan-1,3-dione	$C_{20}H_{19}NO_2$	1.574
14	12.769	2-(Heptyloxycarbonyl)benzoic acid	$C_{15}H_{20}O_4$	16.858
15	12.951	D:A-Friedooleanan-7-one, 3-hydroxy-	$C_{30}H_{50}O_2$	1.455
16	24.650	Phenol, 2,6-bis(1,1-dimethylethyl)-	$C_{14}H_{22}O$	1.214

Table 3: Biological activity of phytocompounds identified in methanolic extract of *T. tetraptera* fruit

Compound name	Molecular structure	Molecular weight	Biological activity
Cyclobut-1-enylmethanol		84	Antibacterial activity[18]
1-Butoxy-1-isobutoxy-butane		202	NA
N-Benzylstearamide		373	Low fatty acid amide hydolase (FAAH) inhibition activity[19]
5-Methoxy-2,2,6-trimethyl-1-(3-methyl-buta-1,3-dienyl)-7-oxa-bicyclo[4.1.0]heptane		236	NA
Tridecane, 2-methyl-2-phenyl-		274	Antibacterial activity[20]
10,13-Octadecadiynoic acid, methyl ester		290	NA
1-Methyl-4-(6-methylhept-5-en-2-yl)cyclohexa-1,3-diene		204	NA
Cedren-13-ol, 8-		220	High ability to inhibit lipid peroxidation[21]

Curcumin		368	Antioxidant. Anti-inflammatory, anti-tumor, anti-angiogenic,[22] wound healing, anticancer, anti-platelet activity, hepatoprotective action[23]
Pthalic acid, butyl undecyl ester		376	Antimicrobial, anti-bacterial, anti-inflammatory[24]
9H-Naphtho[2,1-b]pyran-9-one, 3-thenyldodecahydro-7-(hydroxymethyl)-3,4a,7,10a-tetramethyl-, [3R-(3α,4αβ,6aα,7α,10αβ,10bα)]		320	NA
2-Thiopheneethanol		128	NA
2-(4-Piperidin-1-yl-phenyl)-indan-1,3-dione		305	NA
2-(Heptyloxycarbonyl)benzoic acid		264	NA
D:A-Friedooleanan-7-one, 3-hydroxy-		442	NA
Phenol, 2,6-bis(1,1-dimethylethyl)-		206	Antibacterial, anti-inflammatory activities[25] antioxidant, antifungal and anti-malarial activities [26]

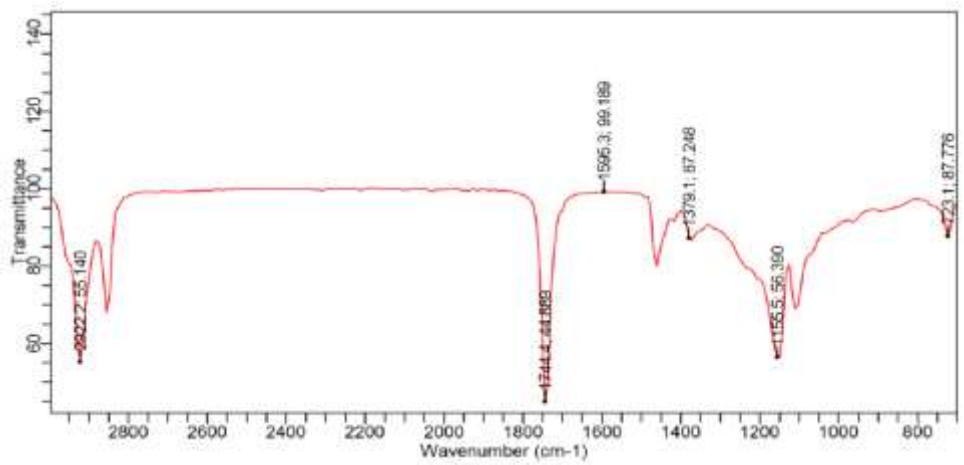


Fig 2: FTIR spectra of the methanol extract of *T. tetrapetera* fruit

Table 4: FTIR Peak values of methanol extract of *Tetrapleura tetraptera*

S/N	Wavenumber (cm^{-1})	Functional group/mode of vibration	Inference
1	2922.2	C-H antisym and sym stretching, Strong peak	C-H, in Alkanes of $-CH_3$ and $-CH_2$
2	1744.4	C=O, C=O stretch, very strong peak	C=O in esters
3	1595.3	Benzene ring, Ring stretch, sharp peak	Benzene rings
4	1379.1	- CH_3 sym deformations, Strong peak	CH_3 in aliphatics
5	1155.5	SO_3H, Stretch, very strong peak	S=O Strech in Sulfonic acids
6	723.1	$-(CH_2)_n-$, CH_2 rocking	CH_2 rocking in methylene chains in hydrocarbons

Table 5: Concentration of Essential amino acids (EAAs) presents in *T. tetraptera* fruit

S/No	Amino acid	Concentration g/100g protein	
		Mean	Standard error
1	Leucine	4.20	0.02
2	Lysine	2.97	0.02
3	Isoleucine	3.11	0.01
4	Phenylalanine	3.37	0.01
5	Tryptophane	0.71	0.02
6	Valine	3.25	0.03
7	Methionine	0.85	0.02
8	Histidine	1.63	0.01
9.	Threonine	2.50	0.02

Table 6: Concentration of Non-essential Amino acids (NEAAs) present in *T. tetraptera* fruit

S/No	Amino acid	Concentration g/100g protein	
		Mean	Standard error
1	Proline	3.05	0.01
2	Arginine	4.30	0.02
3	Tyrosine	2.41	0.02
4	Cystine	0.72	0.03
5	Alanine	4.21	0.01
6	Glutamic acid	7.20	0.01
7	Glycine	3.06	0.03
8	Serine	3.00	0.03
9	Aspartic acid	5.61	0.02

DISCUSSION

The presence or absence of specific phytochemicals in *Tetrapleura tetraptera* methanol extract was determined. Table 1 shows that flavonoids, alkaloids, tannins, reducing sugars, phenols, and terpenoids were abundant, while saponins, glycosides, and steroids were only slightly present. Several researchers have reported the presence of these phytochemicals in studies on various plant parts of this fruit. Nwoba[9] found tannin, saponin, steroid, and terpenoids to be highly present; alkaloids and flavonoids to be moderately abundant; and glycosides to be present in trace amounts in the phytochemical composition of *T. tetraptera* fruit pulp consumed in Abakiliki, Nigeria. In a separate study, these phytochemical constituents were also discovered in *T. tetraptera* raw plant material (leaves, fruit, and stem bark) consumed in Ghana[27]. The presence of these phytocompounds could be attributed to the diverse biological, pharmacological, and therapeutic functions of *T. tetraptera*. Saponin has been shown to have antimicrobial activity and to be effective in the treatment of yeast and fungal infections[9,28]. Tannins, an important component of plant-based medicine, are used in the food industry to clarify beer, wine, and other beverages. It is used as a coagulant in rubber production. Though proteins reduce their bioavailability, it has antiviral, antibacterial, antitumor[9,28,] and antioxidant properties[27]. Several studies have identified alkaloids' pharmacological roles, which include antimalarial, anticancer, antibacterial, analgesic, and anti-diabetic properties. They also have psychotropic and stimulant activities. The antioxidant properties of flavonoids are well known. It has also been demonstrated to have antitumor, antiviral, anti-inflammatory, and hepatoprotective properties. Phenols aid in disease prevention by increasing dietary consumption of antioxidant-rich nutrients[28].

The results of the Gas chromatography-mass spectrometric screening are presented in table 2 and figure 1. Table 2 showed the various phytocompounds identified their retention time, molecular formula, molecular weight, and peak area % (percentage abundance). Sixteen (16) phytocompounds were identified. The most abundant phytocompound identified was 2-Thiopheneethanol (58.771%). Other phytocompounds detected in substantial amount are 2-(Heptyloxycarbonyl) benzoic acid (16.858%), N-Benzylstearamide(4.457%), 10,13-Octadecadiynoic acid, methyl ester(2.491%), Tridecane, 2-methyl-2-phenyl(2.402%). The following phytocompounds were detected though in minimal amount; 1-Methyl-4-(6-methylhept-5-en-2-yl) cyclohexa-1,3-diene(0.791%),1-Butoxy-1-isobutoxy-butane (0.903%), Phenol,2,6-bis(1,1-dimethylethyl)(1.214%),9H-Naphtho[2,1-b]pyran-9-one,3-thenyldodecahydro-7-(hydroxymethyl)-3,4a,7,10a-tetramethyl-[3R(3α,4αβ,6aα,7α,10αβ,10bα)] (1.235%) and 5-Methoxy-2,2,6-trimethyl-1-(3-methyl-buta-1,3-dienyl)-7-oxa-bicyclo [4.1.0] heptanes (1.355%). Some other essential

phytocompounds identified are; Cedren-13-ol, 8-(1.556%), Curcumin (1.057%), Phthalic acid, butyl undecyl ester (1.490%), 2-(4-Piperidin-1-yl-phenyl)-indan-1,3-dione (1.574%), D: A-Friedooleanan-7-one, 3-hydroxy-(1.455%), Cyclobut-1-enyl methanol (2.391%). Some of these identified phytocompounds are without known biological cum medicinal activities. For example, N-Benzylstearamide, a macamide commonly found in the Peruvian plant- *Lepidium meyenii* has demonstrated concentration and time-dependent fatty acid amide hydrolase (FAAH) inhibitory activities [19]. Inhibition of FAAH is crucial as it regulates endogenous concentrations of endocannabinoids[29]. Current researches and treatments of neurological disorders like depression, anxiety, and inflammatory processes consider FAAH inhibition as a potent target[29]. According to Adnan *et al*[18]cyclo-1-enylmethanol, a cyclo-alcohol has demonstrated antibacterial activities. Cedren-13-ol, 8, a sesquiterpene also known as Cedren-13-ol has been reported to be a potent antioxidant[30]. According to Peng *et al* [21], the most prevalent bioactive compound detected in *Vetiveria zizanicoides* essential oil (VZ-EO) is Cedren-13-ol, [8]. The essential oil of *Peucedanum longifolium* according to Tepe *et al*[31] contains a generous amount (33.74%) of Cedren-13-ol, 8 and powerfully inhibited lipid peroxidation. Curcumin a polyphenol derived from turmeric with a characteristically bright yellow coloration is arguably the most pharmacologically diverse bioactive compound detected in the methanolic fruit extract of *T.tetraptera*. Different studies have demonstrated the anti-inflammatory, chemopreventive, chemotherapeutic, and antioxidant activities of curcumin [32,33]. Antitumor, antiangiogenic, anti-cancer, wound healing, hepatoprotective, and anti-platelet activities [22, 23] of curcumin have also been reported. In a different study, Tu *et al* [34] discovered that curcumin can suppress melanogenesis in human melanocytes.

Phthalic acid butyl undecyl ester, a phthalic acid ester (PAE) has been reported to possess diverse biological activities. Phthalic acid esters or phthalates are essential bioactive compounds mostly used as plasticizers[35] produced by plants, fungi, and bacteria[36,37,38]. Antimicrobial, antibacterial, and anti-inflammatory activities of Phthalic acid butyl undecyl ester have been reported by Al-Gara'wi *et al*[24]. According to Dr. Duke`s phytochemical and ethnobotanical Databases[39], phthalic acid butyl undecyl ester serves as a urinary acidulant, suppresses uric acid production, and promotes amino acid decarboxylase activity. It also has anti-tumoral activity[40]. Various concentrations of phthalic acid butyl undecyl ester have been detected in plants such as *Penicillium expansum*[41], *Morganella morganii*[40] *Daedalea elegans*[42], *and Cyperus alternifolius*[24]. Phenol, 2,6-bis(1,1-dimethyl ethyl) is another important bioactive compound detected in the methanol fruit extract of *T. tetraptera*. It is a phenolic compound possessing multiple biological activities such as antioxidant, anti-inflammatory, antifungal, antimicrobial, and anti-malarial activitie[26].

The results of the FTIR analysis as depicted in table 4 and figure 2 revealed 6 peaks that correspond to 6 important functional groups detected. These peaks are of various wavelengths which are; 2922.2cm^{-1}, 1744.4cm^{-1}, 1595.3cm^{-1}, 1379.1cm^{-1}, 1155.5cm^{-1}, and 723.1cm^{-1}. These peaks represent the following functional groups, alkanes, esters, benzene rings, aliphatics, sulfonic acids, and methylene chains common to hydrocarbons respectively. These functional groups confer certain biological characteristics on the plant hence its diverse medicinal effects on the body.

The results of the amino acid composition of *T. tetraptera* fruit that aid to assess its value as a good source of protein are shown in Table 5 (Essential amino acids) and Table 6 (Non-essential amino acids). For the EAAs, leucine, phenylalanine, and valine had the highest concentrations, while glutamic acid, aspartic acid, and arginine had the highest concentrations in the NEAAs. The results of the analysis are in agreement with [43,44].

Aspartic and glutamic acids were the most prominent amino acids in *T. tetraptera* fruit. Although both are NEAAs, glutamic acid is essential for the function of organs[45]. Glutamine is most abundant in the muscle, and its presence allows for the building and maintenance of muscle tissue[44]. Glutamic acid, in combination with glycine, lysine, and threonine, maintains intestinal health[46]. According to Moran-Palacio *et al*., [46] aspartic acid is essential in pyrimidine, purine, inositol, and asparagine synthesis. It is used in the treatment of UTIs and is also involved in the detoxification and excretion of ammonia. Oni *et al* [7] reported that arginine has numerous functions, including the treatment of chest pain, high blood pressure, and pregnancy complications such as pre-eclampsia, as well as erectile dysfunction. Additionally, it enhances the body's defense responses to tumor cells, bacteria, and viral infections. Other amino acids, such as valine, are essential for maintaining mental acuity and muscle coordination; they also regulate the proportion of branched-chain amino acids[43]. Leucine controls protein turnover and gene expression. Alanine plays a crucial role in autophagy, gluconeogenesis, and transamination processes in the liver[44].

CONCLUSION

The result from the phytochemical, GC-MS, FTIR, and amino acid profile of the methanol extract of *T. tetraptera* fruit demonstrated that the fruit could be used as a pharmacological or therapeutic agent in drug discovery as well as a dietary condiment, particularly at this time when there is a demand for novel protein sources.

CONFLICT OF INTEREST

There is no conflict of interest declared.

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