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ORIGINAL ARTICLE

Phytochemical and Antioxidant Analysis of *Artocarpus heterophyllus* Peel Extracts

GEORGIA .C. AGU[1], ISMAIL .B. ONAJOBI[1], OLUWABUKOLA .T. AFOLABI[1], TITILAYO .O. ADESETAN[1], BENJAMIN .T. THOMAS[1], JAMIU .T. ADEYEMI[1], IBUNKUN .T. SOSSOU[2]

AFFILIATIONS:

[1]Department of Microbiology, Olabisi Onabanjo University, PMB 2002, Ago-Iwoye, Ogun State, Nigeria

[2]Department of College of Medical Laboratory Sciences, Redeemer's University, P.M.B. 230, Ede, Osun State, Nigeria

CORRESPONDENCE:

Dr. Oluwabukola T. Afolabi
Department of Microbiology, Olabisi Onabanjo University, PMB 2002, Ago-Iwoye, Ogun State, Nigeria
Email: oluwabukolaafolabi14@yahoo.com

ABSTRACT

BACKGROUND:

Plants have a diverse variety of bioactive compounds such as tannins, alkaloids, flavonoids, carbohydrates and steroids among many others that can offer significant physiological actions in the human body. Phytochemicals are naturally occurring chemical, biological and active compounds found in plants that are of benefit to human health apart from those that act as macronutrients and micronutrients. *A. heterophyllus* (Jackfruit) belongs to the family Moraceae. Jackfruit tree is native to India and is popular in several tropical and sub-tropical Countries.

OBJECTIVE:

The aim of this study is to determine the phytochemical constituents, antioxidant properties and gas chromatography mass spectroscopy (GC-MS) of the fruit peel of *A. heterophyllus* extracts using three different solvents.

METHODS:

Artocarpus heterophyllus fruits were collected from University of Ibadan botanical garden, identified at the Forestry Research Institute of Nigeria, Oyo State. The peel was extracted and dried at 35 ℃. Qualitative method and Gas Chromatography Mass Spectroscopy were used to determine the phytochemical and bioactive compounds present in the plant, whereas 2, 2, Diphenylpicryl-1-hydrazyl (DPPH) was used for the antioxidant analysis.

RESULTS:

Secondary metabolites such as flavonoids, phenols, alkaloids, glycosides, saponins, tannins, steroids, and Terpenoids were present based on the solvents while anthraquinnes were absent. Flavonoid and phenol were abundant in the three extracts while saponin was moderate. Eight chemical compounds were observed in the plant extracts. Major bioactive components with highest and lowest retention peak were (65.55 %) bis(2- ethyl hexyl) phthalate and (6.06 %) Cis- 13(2-ethylhexyl)phthalate respectively. Antioxidant activity increased with increase in concentration of which acetone extract had the highest DPPH (75.00 %) at 100 $\mu g/ml$.

CONCLUSION:

The fundamental means of the usage of medicinal plants for medicine is due to their bioactive properties which are used as substrates for biochemical and enzymatic reactions. Phytochemical derivatives have antiviral, anti-inflammatory, anti-oxidant, immunomodulatory, anticancer, antimicrobial, antitumor, analgesic and many other properties harbor in them.

KEYWORDS:

A. heterophyllus, Antioxidant, Extracts, Gas Chromatography Mass Spectroscopy and Phytochemicals

INTRODUCTION

Studies have shown that some plants have a diverse variety of bioactive compounds such as tannins, alkaloids, flavonoids, carbohydrates and steroids among others that can offer significant physiological actions in the human body [9,13,16,3,8].

Phytochemicals are naturally occurring chemical, biological and active compounds found in plants that are of benefit to human health apart from those that act as macronutrients and micronutrients [21]. The various compounds (phytochemicals) especially secondary metabolites such as flavonoids, phenols, alkaloids, glycosides, saponins, tannins, steroids, anthraquinnes, mucilages, coumarin, oses and holosides found in plants have anticancer, antimicrobial, antiviral, anti-inflammatory, antitumor, analgesic and many other properties [33,15,2]. The fundamental means of their usage for medicine is due to their bioactive properties which are used as substrates for biochemical and enzymatic reactions [36].

Artocarpus heterophyllous (jackfruit) belongs to the family Moraceae [4,19]. The generic name comes from the Greek words 'artos' (bread) and 'karpos' (fruit); The specific name, '*heterophyllus*', in Latin means, with leaves of different sizes and shapes and the word "heteros" in Greek corresponds to the word 'different'. The word "jackfruit" comes from Portuguese jaca, which in turn, is derived from the term 'chakka' in Malayalam language. The ancient Indian language Sanskrit refers this fruit as Atibruhatphala[6]. Jackfruit tree is native to India and is popular in several tropical and sub-tropical countries. The fruit is known as the 'poor man's fruit' in eastern and southern parts of India because it is a major part of their diet as a vegetable and nutritious dish during its fruiting season [1]. The ripe fruit contains well flavored yellow sweet bulbs and seeds. The edible bulbs of ripe fruits are consumed fresh or processed into canned products. Jackfruit flavour is a blend of tropical fruits, including pineapple (*Ananas comosus*), banana (*Musa paradisiaca*), mango (*Mangifera indica*), orange (*Citrus sinensis*), melon (*Cucumis melo*), and papaya (*Carica papaya*), which gives it an exotic quality [39], this research was also supported with the work done by [35], that in terms of production volume, it comes in fourth behind banana, mango, and pineapple. The majority of the weight of the fruit is typically made up of the seeds, which are typically light brown in color, oval, oblong, ellipsoid, or spherical in shape, and measure 2-3 cm in length and 1-1.5 cm in diameter [31]. In each fruit, there can be up to 500 seeds. They are recalcitrant and may be kept for up to a month in cool, humid conditions [31].

It originated from New Guinea and extensively grows in the Southern parts of India. The multifarious importance of different parts of breadfruit (latex, leaf tips, and inner bark) includes food, cosmetics, medicine, clothing material, construction materials and animal feed [29,12].

The strongest antioxidant ability is seen in jackfruit axis extract, which is more effective than vitamin C at preventing cytotoxicity from alcohol [25]. Through its phytonutrients, such as carotenoids, jackfruit demonstrates anti-oxidative action and protects tissues from oxidative damage [34,26].

Jackfruit peel has also been tested for its suitability utilizing a variety of methods, including microwave-induced NaOH activation [17] and phosphoric acid activation [30], to be used as an efficient raw precursor for the production of activated carbon. These tests aim to increase the economic value, decrease the cost of waste disposal, and provide a potentially cheap raw material for commercial scale activated carbon production that in turn prevents deforestation. Additionally, jackfruit peel can be used to make bio-oil, a resource that can replace nonrenewable fossil fuels [42]. Jackfruit rags can be used as a natural photo-sensitizer for dye-sensitive solar cells as part of an investigation into upcycling waste products for energy production. It is essential to investigate the effectiveness of the rind exterior of *A. heterophyllus* extracts to avoid wastage of the fruit peel in other to make the peel acceptable scientifically and commercially.

METHODS

The *A. heterophyllus* fruits were collected from the University of Ibadan, Botanical garden, and then authenticated at Federal Research Institute of Nigeria

(FRIN), Jericho, Ibadan, Oyo State with authenticated number 113188.

Phytochemical Analysis of *A. heterophyllus* Fruit Peel

The fruit peels of *A. heterophyllus* plant were extracted by cutting into pieces with the aid of sterile machete, air dried at room temperature (35 ± 2 ^{0}C) for 6 weeks and crushed using mortar and pestle then blended into smaller particles using electric blender (LEXUS USHA) to obtain semi-powered material and store for further use at 4^{0}C in a tight water free plastic bottle [22].

Plant extraction

Polar and non- polar solvent (Aqueous, Ethyl-Acetate and Acetone) was used for the extraction. Plant extracts were prepared by maceration of the particles. Two hundred gram (200g) of the particles were soaked in 1000 ml of each solvent (Aqueous, 100% Ethyl-acetate (non-polar) and 100% Acetone (polar)) for 72 hours at room temperature. Extracts were then filtered using Whatman grade 1 filter paper and concentrated using rotary evaporator (IKA® RV 05 basic) at 45^{0}C. Concentrated extracts were weighed to find the extraction efficiency on dry weight basis. The dried extracts were stored in airtight container separately at 40^{0}C for further use [22].

Phytochemical Screening

Quantitative method described by [44,38,37] was adopted in screening for the phytochemicals present in the plant part under study (*A. heterophyllus* fruit peel).

Method of screening on each of the extraction (Ethyl-acetate, Acetone and Aqueous)

Phytochemical analysis of the crude extracts was performed according to the method described by [11,18].

Test for Flavonoids:

When 1.0 ml of the extracts from each test tube was mixed with 1.0 ml of 10% lead acetate, the presence of flavonoids would be shown by the formation of a yellow precipitate.

Test for Tannins:

Five grams (5.0 g) of the extracts was stirred with 10 ml of distilled water. Mixture was filtered, and ferric chloride reagent was added to the filtrate. The presence of tannins would indicate blue-black precipitate.

Test for Terpenoids:

Three milliliters (3 ml) of concentrated sulfuric acid and 0.5 ml of the dried extracts were heated for ten minutes on a water bath then evaporate to dryness. The development of a gray hue would indicate the existence of terpenoids.

Saponins Test:

An experiment with foam was performed to test for saponin. In each test tube, 2 milliliters of extracts were mixed with 6 milliliters of water. For the presence of saponin to be detected, the mixtures were vigorously shaken in order to identify persistent foam.

Test for Steroids:

In a test tube, 0.5 g of the dried extracts was extracted with 2.5 ml of chloroform, and a lower layer was created by adding 1 ml of concentrated sulphuric acid. A reddish-brown interface would indicate the presence of steroids.

Anthraquinone Test:

A dry test tube containing 1.0 g of the peel extracts were added to fill up 20 ml of chloroform, set on heat for five minutes in a steam bath. The extract was filtered immediately and allowed to cool. The filtrate was mixed with an equal volume of 10% ammonia solution. After shaking the mixture, the upper aqueous layers were then examined for pink coloration which indicates the presence of anthraquinones.

Test for Phenol:

A 2% solution of Ferric chloride ($FeCl_3$) was dissolved in 2 ml of crude extract. The presence of phenol was identified by a blue-green or black coloring.

Alkaloid Test:

Two milliliters (2 ml) of Wagner's reagent were combined with the crude extracts. The presence of alkaloids is indicated by reddish brown coloration precipitate.

Test for Phytosteroids:

To test for Phytosterols, Salkowski test was employed. Chloroform and concentrated H_2SO_4 were both added

to 2 ml of the aqueous extract. The remedy was vigorously shaken. As a result, the acid layer showed the presence of greenish yellow fluorescence, and the chloroform layer turned red.

Gas Chromatography Mass Spectroscopy Analysis

The volatile components of various extracts from jackfruit peel were analyzed using Thermo MS DSQ II (DB 5 - MS Capillary Standard Column for Ethyl-acetate, Acetone and Aqueous extract), injector and oven temperature was 70°C raised to 260°C. The heating rate was programmed at 6°C/minutes. The injection was performed in the split ratio of 260 and the volume was 1µL. The flow of carrier gasses was maintained at 1.0ml/minutes all through the run.

The identification of the compounds was performed by similarity searches and mass spectra data using MS Search 2.0 Library [40]. The quantification of components was done by relative peak areas calculation.

Antioxidant Analysis

Free radical scavenging test using 2, 2-diphenylpicrylhdrazyl (DPPH)

The bleaching or discoloration of the purple color of 2, 2 Diphenyl-1-picryl hydrazyl (DPPH) was used to measure the free radical scavenging activity of extracts at various concentrations [14]. *A. heterophyllus* fruit peel extracts in water, acetone, and ethyl acetate were examined for antioxidant properties. To 1.4 ml of DPPH, 0.1ml solution of various extracts strength was added, and the mixture was left in a dark place for 30 minutes. Shimadzu UV/VIS NIR 3600 was used to measure the absorbance at 517 nm, and the following equation was used to compute the percentage inhibition.

Percentage inhibition (%) = (A0 –A1) / A0 × 100

Where; A1 represents the absorbance of the test solution and A0 represents the absorbance of the control solution. The results can also be represented in terms of IC50 value which is the effective concentration at which the antioxidant activity is 50 %. The standard antioxidant used is Ascorbic acid.

RESULTS

PHYTOCHEMICAL ANALYSIS

Yield value of *Artocarpus heterophyllus* fruit peel

In this experiment, 200 grams of dried sample was used for extraction using 1000ml of each solvent. Aqueous exhibited the highest percentage yield i.e 5.29% and the least yield was acetone which was 2.39% while Ethyl acetate was 3.1% as shown in the table 1:

To calculate the percentage yield;

n/g × 100

key: n = number of the dry extract

g = gram of the dried sample

Table 1. Percentage yield value of *Artocarpus heterophyllus* fruit Peel

S/N	Solvent	Sample(mg)	Yield in gm	Yielded %
1	Ethyl acetate	200	6.20	3.10
2	Acetone	200	4.77	2.39
3	Aqueous	200	10.58	5.29

Phytochemical Screening

The active ingredients present in *Artocarpus heterophyllus* peel are shown in table 2 below. Ethyl acetate showed the presence of Alkaloid, Saponin, Steriod, Flavonoid, Terpenoids, Phenol and Phytosteriods; Acetone showed the presence of Alkaloid, Saponin, Flavonoid, Tannin, Terpenoids, Phenol and Phytosteriods, whereas Aqueous showed the presence of Saponin, Steriod, Flavonoid, Tannin and Phenol.

Table 2. Presence of phytochemical constituent in *A. heterpphyllus* peel.

Phytochemicals	Ethyl acetate	Acetone	Aqueous
Alkaloid	+	+	-
Saponin	+	+	+
Steroid	+	-	++
Flavonoid	++	++	++
Tannin	-	+	+
Terpenoids	+	+	-
Phenol	++	++	++
Phytosteroids	+	+	-
Anthraquinones	-	-	-

Keys; ++ = Moderate, + = Trace and - = Absent

GAS CHROMATOGRAPHY MASS SPECTROSCOPY ANALYSIS (GC-MS)

The result of GC-MS analysis of the various extracts (Ethyl-acetate, Acetone and Aqueous) identifies different compounds present in *Artocarpus heterophyllus* fruit peel.

The main constituents found in the ethyl acetate extract were Bis (2-ethlyhexyl) phthalate, which had the highest Retention Peak (RP) area with 65.55% as shown in Figure 1, Tridecanoic acid, 12-methyl-methyl-Ester, and Dibutyl phthalate, which had the lowest Retention Peak (RP) with 6.06% and Dibutyl phthalate, which had the lowest RP with 13.48 depicted in figure 2.

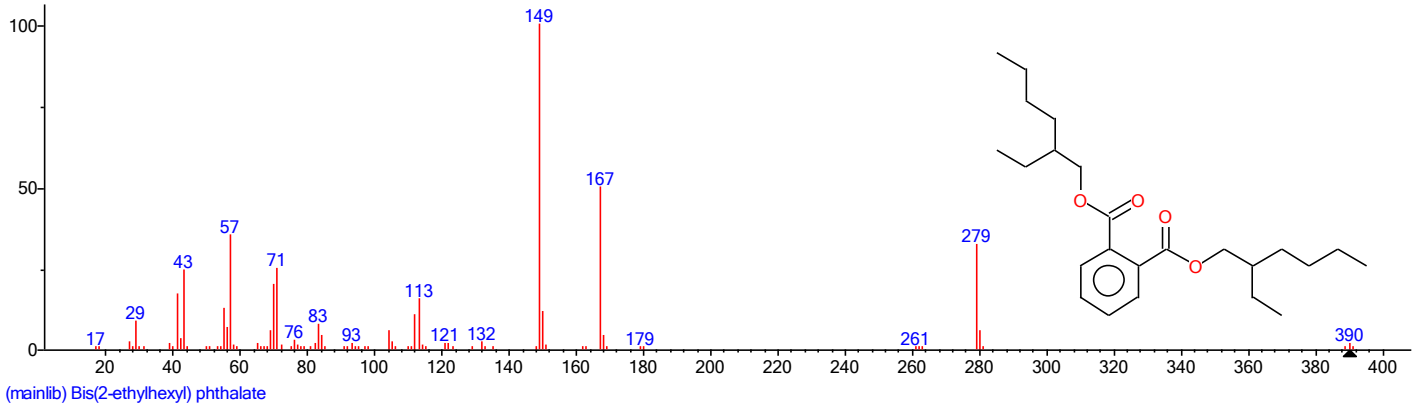

Figure 1. Retention peak and mass spectrum obtained by GCMS of ethyl acetate Sample containing Bis (2-ethylhexyl) phthalate (65.55%).

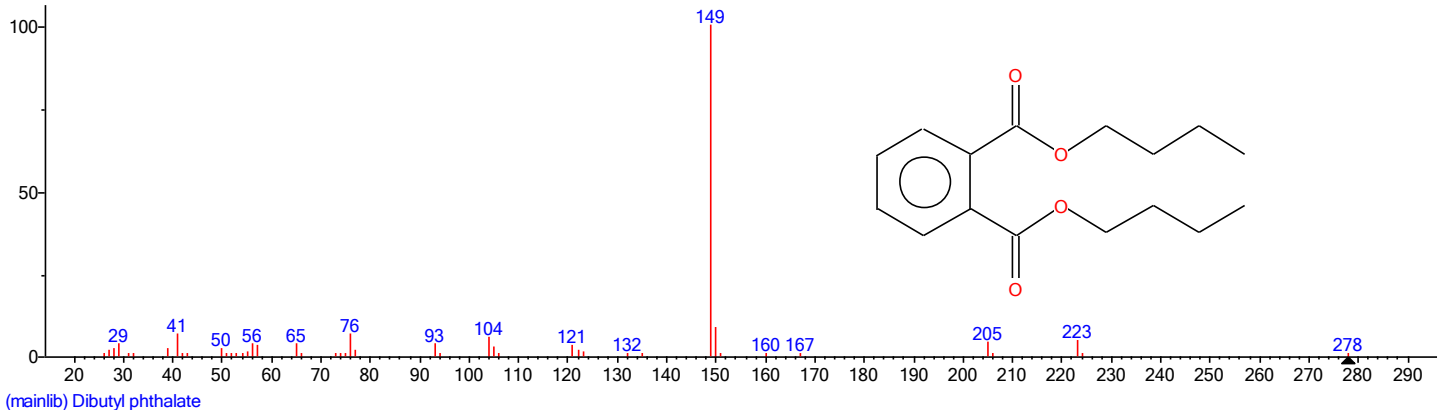

Figure 2. Retention peak and mass spectrum obtained by GCMS of ethyl acetate Sample containing Dibutyl phthalate (13.48%).

Acetone Extract

The major compounds identified were Hexadecanoic acid, Methyl Ester with 11.59% as the Retention Peak (figure 3) as the highest, followed by Cis- 13 – octadecenoid acid with Retention Peak of 5.15% as shown in figure 4, Oleic acid with 3.058% Retention Peak, 7, 10- Octadecadienoic acid, Methyl Ester and Octadecanoid acid, Methyl Ester with 0.965% Retention Peak. Octadecenoid acid, Methyl Ester with 0.79% RP , Cis- vaccenic acid with 0.531% RP and Tridecanoid acid, 12- Methyl Ester with 0.45% RP.

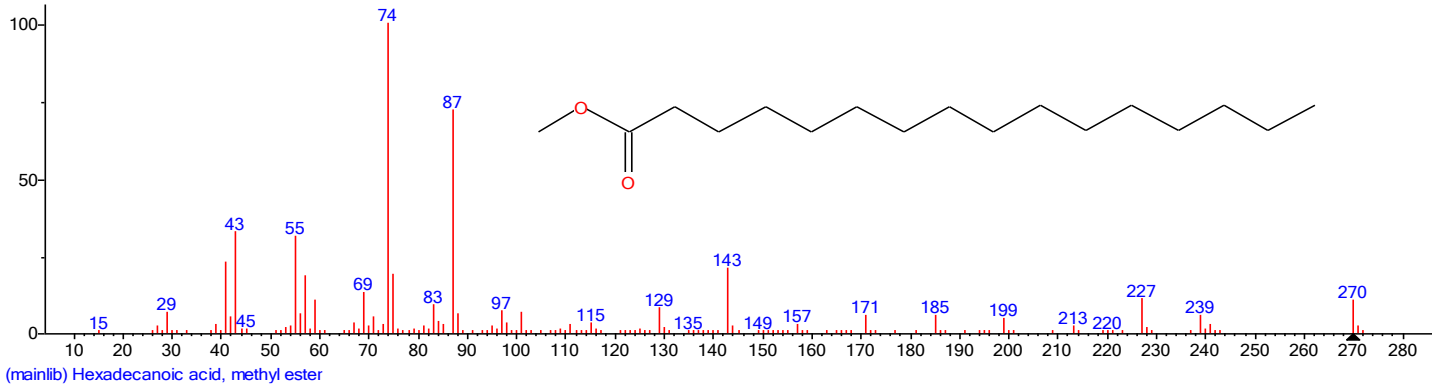

Figure 3. Retention peak and mass spectrum obtained by GCMS of acetone Sample containing Hexadecanoic acid, methyl ester (11.59%)

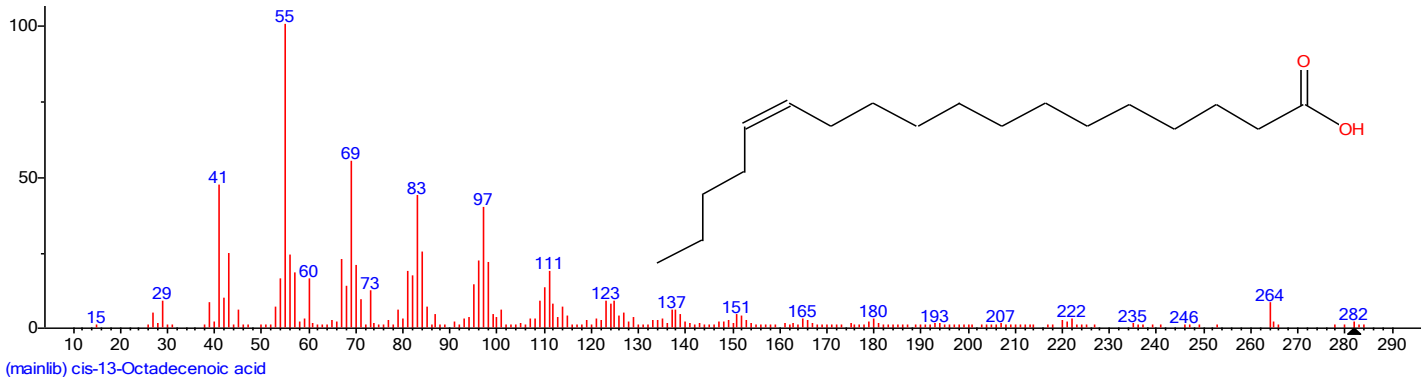

Figure 4. Retention peak and mass spectrum obtained by GCMS of acetone Sample containing Cis-13-octadecenoid acid (5.15%)

Aqueous Extract

Bis (2-ethylexyl phthalate) was one of the chemical compound found in the aqueous extract, and it had the highest Retention Peak at 64.31% (figure 6). It was followed by n-Hexadecanoid acid with 3.91% RP, 11-octadecenoid acid, DMOXderivatives with 3.8% RP, and Hexadecamoid acid, Methyl Ester with 15.04% RP (figure 5), 5-Hydoxymethylfurfural with 6.7% RP, and Benzeneethanol, 4-hydroxyl with 6.08% RP.

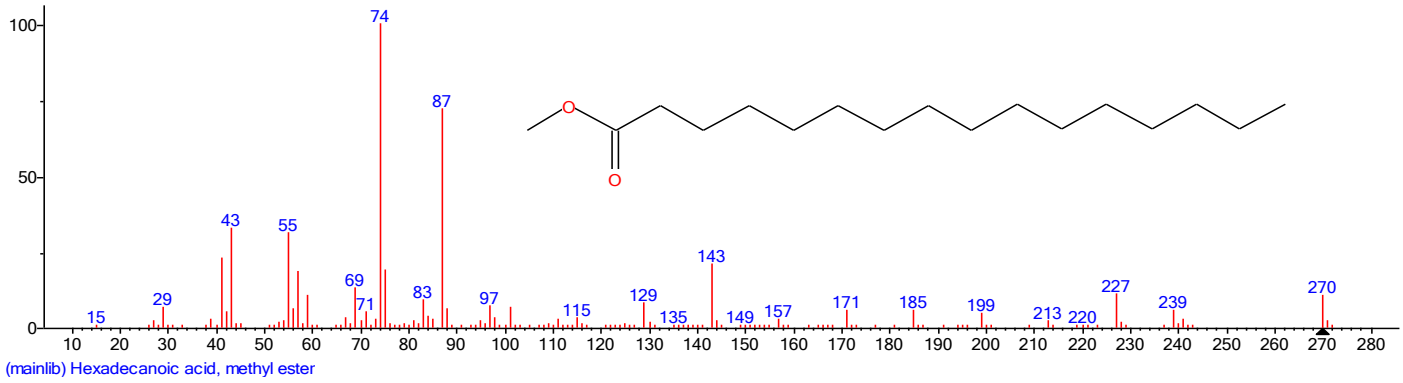

Figure 5. Retention peak and mass spectrum obtained by GCMS of aqueous Sample containing Hexadecanoid acid, methyl ester (15.04%)

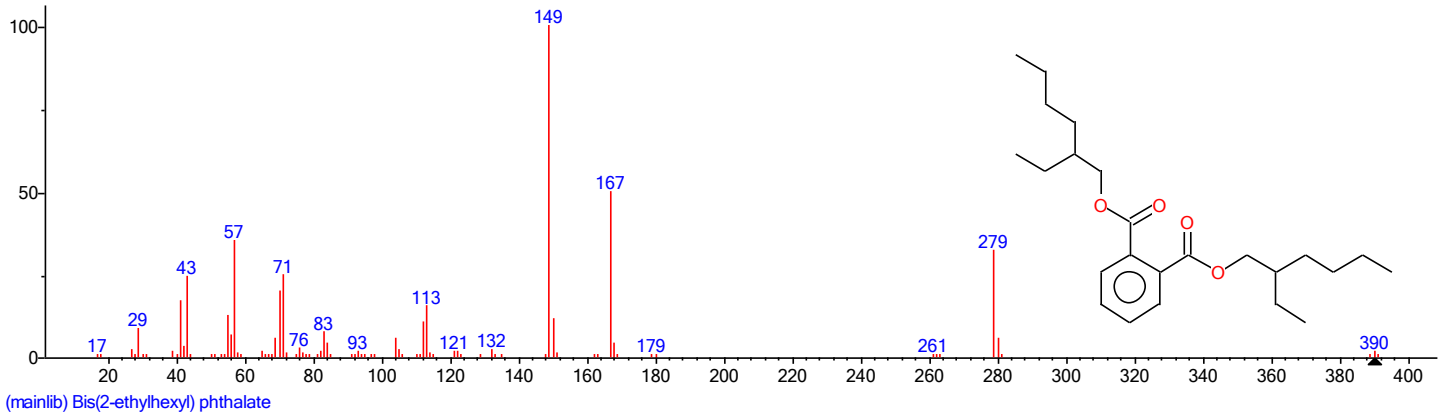

Figure 6. Retention peak and mass spectrum obtained by GCMS of aqueous Sample containing Bis(2-ethylhexyl phthalate (64.31%)

ANTIOXIDANT ASSAY

Antioxidant analysis was performed using four µg/ml, namely25 µg/ml, 50 µg/ml, 75 µg/ml, and 100 µg/ml, on the three crude extracts of *A. heterophyllus* fruit peel. The extracts were tested for their ability to scavenge Diphenyl picryl hydrazine (DPPH) radicals, Nutric oxide (NO), Reducing power, Total antioxidant, Total phenol, and Total flavonoid.

Scavenging Effect of Acetone, Ethyl acetate and Aqueous Extract of *A. heterophyllus* on DPPH Radicals.

As shown in figure 7 below; all the extract inhibited DPPH radical in a concentration dependent manner. At the concentration of 100 µg/ml acetone, ethyl acetate and aqueous extracts have maximum inhibition of 75.00, 70.86 and 72.43 % compared to that of ascorbic Acid (83.25 %) at the same concentration.

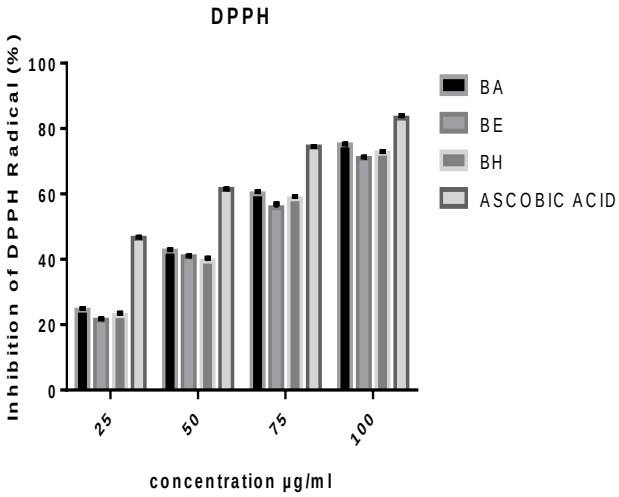

Figure 7. Concentration dependent inhibition of DPPH radical by acetone, ethyl acetate and aqueous extract of *A. heterophyllus* compared to ascorbic acid.

Nitric Oxide Scavenging Activity

In figure 8; the scavenging of NO was found to increase in dose dependent manner. Maximum inhibition of NO was observed in the highest concentration (100 µg /ml) for all the samples. At this maximum concentration, inhibition was found to be 75.00%, 72.425% and 70.86% for acetone, ethyl acetate and aqueous respectively compared with 88.66% for ascorbic acid.

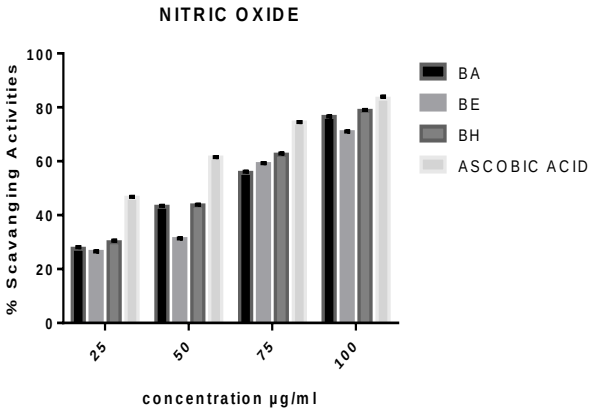

Figure 8. Concentration dependent scavenging of NO by extract of by acetone, ethyl acetate and aqueous extract of *A. heterophyllus* compared to ascorbic acid.

Total Antioxidant, Total Phenolic and Flavonoid:
For Flavonoid; acetone has highest total flavonoids content of (39.05) followed by ethyl acetate extract (35.19) and aqueous extract has lowest flavonoid content of (33.60) mg of Quercetin equivalent/100g weight of the extract respectively. Unlike flavonoid, the phenolic content in acetone, ethyl acetate and aqueous extracts were (25.33, 26.54, 28.38 mg gallic acid equivalents / g dry weight extract) respectively. Total antioxidant follows the same pattern with total flavonoid acetone extract has highest total antioxidant capacity of (47.71) followed by ethyl acetate with (46.56) and the aqueous has the lowest antioxidant activities of (43.75) mg/100g of Ascorbic Acid equivalent as shown in figure 9 below.

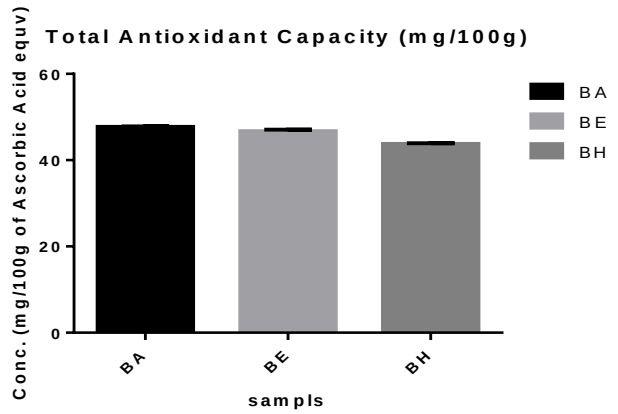

Figure 9. Total antioxidant activities of acetone, ethyl acetate and aqueous extract of *Artocarpus heterophyllus* compared to ascorbic acid.

The Reducing Power of Acetone, Ethyl-Acetate and Aqueous Extract of *A. heterophyllus*
As shown in figure 10 below, the reducing power was found to significantly increase in a concentration dependent manner. At 100 µg/ml concentration; the acetone, ethyl acetate and aqueous extracts shows maximum reducing power of (0.423, 0.412 and 0.394) respectively compared to that of ascorbic Acid (0.625) at the same concentrations.

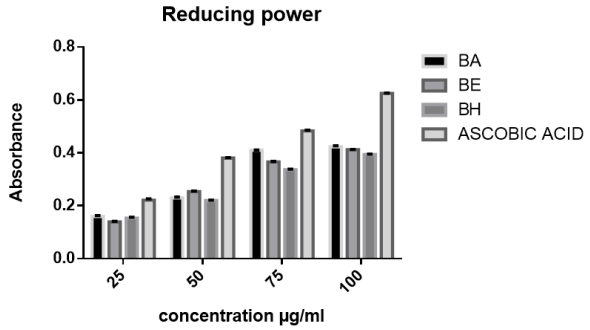

Figure 10. Concentration dependent reducing power antioxidant activities of acetone, ethyl acetate and aqueous extract of *A. heterophyllus* compared to ascorbic acid.

DISCUSSION

The study provides valuable insights into the phytochemical composition of *A. heterophyllus* peel extracts, affirming its richness with various bioactive compounds identified by gas chromatography mass spectroscopy and potential medicinal properties using 2,2 phenyl-1-pircyl hydrozyl (DPPH) for antioxidant analysis.

The present study on phytochemical analysis revealed the presence of Alkaloid, Saponin, Steroids, Flavonoids, Terpenoids, Phenol and Phytosteroids in Ethyl-Acetate extract. According to[23,7,32], the stem bark of *A. atilis* confirm the presence of Terpenoids, Flavonoid, Alkaloids and Tannin. The phytochemical components in jackfruit may differ and depends on the cultivation as well as habitat and plant parts, this is also supported according to work done by [6]. Acetone showed the presence of Alkaloid, Saponin, Flavonoid, Tannin, Terpenoids, Phenol and Phytosteroids whereas Aqueous showed the presence of Saponin, Steroid,

Flavonoid, Tannin and Phenol. This was also confirmed from the work done by [43]. The fruit peel was extracted using ethyl acetate, acetone and aqueous using soxhlet apparatus. The semi solid extract obtained were aromatic, pale and dark brown in color. The extracted value was found to be 6.20g for ethyl acetate, 4.77g for acetone and 10.58g for aqueous extract. This was also established by work of[43]. The preliminary phytochemical screening tests might be useful in the detection of bioactive principles and revealed the presence of flavonoids, tannins, carbohydrate, saponins, alkaloids, tannins, triterpenoids, proteins in the ethanonic peel extract [46]. The presence of these compounds, Tridecanoid acid, 12-methyl-, methyl ester, Hexadecanoic acid, methyl ester, 7,10-octadecadienoic acid, methyl ether, octadecenoid acid, methyl ester, and Cis-13-octadecenoid acid, octadecadienoic acid, methyl ester are all present in the acetone extract analysis. Tridecanoic acid, 12-methyl-methyl ester, dibutyl phthalate, cis-13-octadecenoic acid, and bis (2-ethylhexyl) phthalate are all detected in ethyl acetate extract. 5-0- Hydroxymethylfurfural, Benzeneethanol, 4-hydroxy, Hexadecanoid acid, methyl ester, n-Hexadecanoid acid, 11-Octadecenoid acid Bis(2-ethylhexyl phthalate) are organic compounds detected in the extracts which could be responsible for the potency of the plant peel against inflammation and according to[24], the activities of some phytochemicals with compound nature of flavonoids, palmitic acid (hexadecanoic acid) as antimicrobial, antioxidant hypochlolesteremia, cancer preventive, hepatoprotective and anti-coronary. According to [20], the major compounds present in the methanolic extract of peel as identified by Gas Chromatography - Mass Spectroscopy was Calophyllolide with 34.14 RT (retention time), and 38.64 % relative peak area and other various compounds present in the Jackfruit peel powder.

All the extract of *A. heterophyllus* peel exhibited a good Nitric oxide (NO) scavenging activity leading to the reduction of the nitrite concentration. This suggests potential use in preventing lipid peroxidation and as a therapeutic agent against oxidative and non-oxidative damages caused by reactive oxygen and nitrogen species which is supported by the research of Ebrahimzadeh [14] who connected reactive oxygen to food deterioration and chronic diseases, including the phenolic compounds' and antioxidant activity to redox properties because of the NO scavenging activity present in the bark of *A. heterophyllus* plant. In the assay medium, the scavenging of NO was found to increase in dose dependent manner for all the samples for the extract, inhibition was found to be significantly higher in both Acetate and Aqueous extract (75%, 72.425%) compared to Ethyl acetate extract (70.86) but significantly reduced compare to the Ascorbic Acid (82.66%) (Standard), similar observations were found at all concentration in dose dependent manner.

The DPPH assay has been largely used as a quick, reliable and reproducible parameter to search for the in vitro antioxidant activity of pure compounds as well as plant extracts [5]. The extract showed a potent DPPH radical scavenging potential. All the extracts inhibited DPPH radical in a concentration dependent manner. At the concentration of 100 µg/ml Acetone, Ethyl acetate and Aqueous extract have maximum inhibition of 75.00, 70.86 and 72.43 % compared to that of ascorbate (83.25 %) at the same concentration. Acetone has the highest DPPH concentration at 75.00% compared to others. The decrease in absorbance value occurs due to the electron transfer of the antioxidant hydrogen atom to DPPH. IC50 of each extract can be calculated by plotting the concentration of the test solution and the percentage of inhibition of DPPH as a parameter of antioxidant activity. According to studies by[41], the IC50 for the bark extract was 33.93 mg/ml and 52.08 mg/ml for the jackfruit leaf extract that was obtained.

The reducing capacity of a compound may serve as a significant indicator of its potential antioxidant activity according to[5]. The reductive ability was measured in terms of Fe^{3+} to Fe^{2+} transformation in the presence of different concentrations of the extract. The presence of reductants in extracts causes the reduction of potassium hexacyanoferrate K_3FeCN_6 to the ferrous form. Therefore Fe^{2+} can be monitored by measuring the absorbance, where it is directly proportional to the reducing power of test substance. Earlier authors have observed a direct correlation between antioxidant activities and reducing power. The reducing ability of a compound generally depends on the presence of

reductants, which have been exhibited in antioxidative potential by breaking the free radical chain, by donating a hydrogen atom[5]. According to research by [27], the reducing power of the roots, leaves, and bark varied from 114.38 to 93.62 g/ml, 71.63 to 67.04 g/ml, and 54.16 to 33.15 g/ml, respectively.

Dichloromethane methanol 1:1 extract was shown to have a higher reducing power (16.678 g GAE/mg) than acetone (14.029 g GAE/mg) extract[19]. Conferring to reports, pulp methanolic extract had FRAP of 5 mg/ml [45]. At doses of 0.2, 0.4, and 0.6 mg/ml, respectively, 70% ethanol had 62, 75, and 78% of Fe++ chelating activity [28].

Considering the observed antioxidant potential of the investigated Acetone, Ethyl acetate and Aqueous extract of *A. heterophyllus* and the potent DPPH radical, OH radical, O_2 – radical, NO scavenging activity, it could be presumed that this extract is able to prevent lipid peroxidation and further suggest that the extract is a potential therapeutic agent for the control of oxidative and non-oxidative damage caused by reactive oxygen and nitrogen species. The results have demonstrated that all the extracts (Acetone, Ethyl acetate and Aqueous) possessed antioxidant and nitric oxide scavenging abilities, which indicates that the plant contains certain compounds which are potential anti-oxidants. Due to the potent free radical scavenging activity of the *A. heterophyllus* it was subjected to some phytochemical analysis, total phenolic and flavonoid compounds were the major classes of bioactive components assayed for in the extract based on the quantitative analysis. Colorimetric determination of flavonoids in plants, utilizing Aluminium chloride (AlCl) reagent, is an established method to quantify total flavonoid content. For the Acetone, Ethyl acetate and Aqueous extract, total flavonoids were found to be (39.05%, 35.195% and 33.605%) mg of Quercetin equivalent/100g weight of the extract respectively. This result shows that the Acetone extract at 39.05% has higher content of total flavonoid. Phenolic compounds may contribute directly to anti-oxidative action. Unlike flavonoid, the phenolic content in Acetone, Ethyl acetate and Aqueous extract were (25.33, 26.54, 28.38 mg gallic acid equivalents / 100g dry weight extract) respectively which shows that aqueous has higher phenolic content compared with both Acetone and ethyl acetate. The antioxidant activity of plant phenolic compounds are attributed to their redox properties, which allow them to act as reducing agents, hydrogen donators, singlet oxygen quenchers and metal chelators [10].

The data obtained from the research revealed varied constituents present in the three extracts. From the results, flavonoids and phenol were abundant, saponin moderate and anthraquinonone were found to be absent in the extracts for phytochemical analysis and this may be due to environmental and climate difference. Fractionalization by GC-MS identified different organic compounds based on each extracts with their area percentage, hexadecanoic acid methyl ester and Bis(2-ethylhexyl)phthalate were commonly found in all the 3 extracts with the highest area percentage, whereas, acetone had the highest total antioxidant and flavonoid content as well as the DPPH radical in all the concentrations used and aqueous extract had the highest phenolic content.

The novelty of this research is that *A. heterohyllus* peel which is a bio-agro product contains phytochemical and bioactive compounds that are every important in fighting against infections and diseases in humans. Thus, turning bi-agro waste into useful and acceptable products based on the modest compounds found in them. These secondary metabolites are renowned for their broad-spectrum pharmacological properties and antioxidant effects in medicinal applications such as reducing inflammation, preventing DNA damage, aiding DNA repair, accelerating blood clotting, reducing blood pressure, inflammation as well as tissue damage and modulating immune responses.

CONCLUSION

According to the results of the current study, extracts from the peel of *A. heterophyllus* (Lam) include certain organic chemical components, secondary metabolites, and antioxidants. Numerous secondary metabolites, including tannin, terpenoids, alkaloids, flavonoids, phenol, steroids, glycosides, and phytosteroids, are present in the peel. The chemical composition of the peel extract and the presence of hydrocarbons fractioned by gas chromatography mass

spectroscopy were assessed. The DPPH method was used to test the peel extract's in vitro antioxidant capacity, and the results show that it has a modest level of antioxidant activity and this study shows that *Artocarpus heterophyllus* has a potent nitric oxide and scavenging activity. In order to increase the economic value of *A. heterophyllus* peels and lower the cost agro waste disposal, it is advisable that the plant peel is adopted as a source of natural biochemical; antioxidant and it can as well serves as antibacterial agent.

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CONFLICT OF INTEREST

No conflict of interest was declared by the authors regarding the publication of this manuscript.

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