

# DETERMINATION OF PHYSICAL AND PHYTOCHEMICAL CONSTITUENTS OF SOME TROPICAL TIMBERS INDIGENOUS TO NIGER DELTA AREA OF NIGERIA

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## Abstract

Selected timbers indigenous to Niger delta area of Nigeria were identified and their physical properties and phytochemical constituent (qualitative and quantitative determination) check conducted. The result of the physical properties showed that: the highest porosity index was 1.75 % from *Phyllanthus discoideus*, the highest specific gravity recorded was 0.54 for *Sacoglottis gabonensis*, the highest charring temperature of 97-110 °C was recorded for *Pycnanthus angolensis*. Moisture contents of the range 16 % in *Cassipourea barteria* was the lowest while 33 % was the highest in *Bombax brevicuspe*. All the timber samples were acidic with the exception of *Glyphaea brevis* which is neutral with a pH of 7.18. All the timbers were soluble in hot conc. H<sub>2</sub>SO<sub>4</sub>. Qualitative phytochemical studies showed that almost all the phytochemicals except phlobatannins are present in varied form in almost all the timber samples examined. Quantitative determination of the phytochemical constituents showed that: *Cola laurifolia* and *Bridelia micrantha* with contents of 1180mg/g and 1160mg/g had the highest tannin, while the least recorded was 620mg/100g found in *Lovoa trichiliode*, 80 % of the timber samples analysed had above 6 % of flavonoids in them, cynogenic glycoside recorded in each of the wood samples was less than 1000 mg/g with the highest contents of 891 mg/g, 859 mg/g and 810 mg/g found in *Phyllanthus discoideus*, *Cassipourea barteri* and *Bridelia micrantha*. *Bridelia micrantha* and *Homalinum letestui* with values of 5.84

g/100g and 5.34 g/100g respectively contain the highest quantity of oxalate, *Phyllanthus discoideus* and *Rhizophora racemosa* with values of 11.6 % and 12.2 % had the highest quantity of alkaloids and saponin respectively. These qualities possessed by the examined timbers shows that apart from their properties in building and other constructions, they are good sources for dye production, agro-chemicals and pharmaceuticals due to their phytochemical constituents.

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**Keywords:** Niger delta, timbers, Physical, Phytochemicals, constituents

## **Introduction**

The ubiquitous nature of wood has made it a valuable material in every stage of human development. This is well captured in the words of Fuwape (2000) that at the early age, the baby rests in wooden cot, plays with wooden toys, and learns to write on wooden slate and paper when he is of school age. On graduating from school he receives a paper certificate, if he is lucky to secure employment his salary is paid in paper currency. When he is old he uses a wooden walking stick, sleeps on wooden bed and when he dies the body is laid in wooden coffin. Wood is very important in the world today so much so that its importance is innumerable.

Niger delta area of Nigeria is a densely populated region in Nigeria which in the past was referred to as “oil rivers” because it was once the major producer of palm oil in the glorious days of agricultural boom in Nigeria before the discovery of crude oil. The area was the British Oil Rivers Protectorate from 1885 until 1893 when it was expanded and became the Niger Coast Protectorate (Hogan, 2013). The region covers about 70,000 km<sup>2</sup>, making up 7.5% of Nigeria’s land mass. Present day delta area of Nigeria is made up of 9 states viz: Bayelsa, Delta, Rivers, Abia, Akwa Ibom, Cross River, Imo, Edo and Ondo States. Niger delta is associated with regions in Nigeria where crude oil is produced (crude oil producing states). This area is made up of mangrove swamp vegetation with diverse species of both plants and animals. It is the hub of timber logging in Nigeria as well as center of herbal drug sources.

Wood has been used for centuries for needs varying from farming tools to building materials, from fuel to weapons of hunting and warfare. It remained virtually the most predominant material used for construction of houses, barns, fences, bridges, furniture items, musical instruments and energy generation (Douglas 1995). Wood and wood products have contributed significantly to developments in education, communication, entertainment, sports and industrialization.

In Nigeria, over four thousand six hundred (4600) plant species and three hundred and fifty (350) timbers have been identified (Eboatu *et al.*,

1990 and Akindele and Lemay 2006), but this is without investigation of their chemical constituent like those of the timbers in developed countries. Akharaiyi *et al.* (2012) studied the antibacterial, phytochemical and antioxidant activities of the leaf extracts of *Gliricidia sepium* and *Spathodea campanulata*, and noted the differences in the chemical components of the plants' extracts such as tannins, alkaloids, phenols, flavonoids and saponins. Compaore *et al.* (2011) carried out a comparative study on the composition and antioxidative properties of seeds of *Moringa oleifera* and the pulps of *Parkia biglobosa* and *Adansonia digitata* commonly used in food fortification in Burkina Faso. From the literature, lots of work has been done on the chemical constituents of the seeds, leaves and parts of plants of tropical timbers, but it appears there is limited/no records on the physical properties and phytochemical constituents of woods of these tropical timbers especially those of Niger delta area of Nigeria, hence the need of a work in this direction. This therefore, is the reason for carrying out this work to determine the physical and phytochemical constituents of some timbers indigenous to Niger delta area of Nigeria as this will help to establish facts about their biochemical and pharmaceutical applications.

## **Materials and methods**

### **Materials**

The wood samples were obtained from timber markets in Enugu (Enugu State), Abakaliki (Ebonyi State), Okada (Edo State), and Nnewi (Anambra State) all in Nigeria. These wood samples were carefully selected from sawed healthy timbers identified and their local names obtained from timber dealers, confirmed by botanist and literature (Keay *et al.*, 1964). The timber dealers were able to give the local or common names of the timbers while the botanical names were obtained with the aid of Forest Officers and the literature (Keay *et al.*, 1964).

### **Wood Sample Preparation**

Fourteen well grounded fine powdered timber samples were obtained using Angle grinder/polisher (Siemens, Germany). The powdered samples were kept in air- tight polyurethane bags in cool dry cabinets until required.

## **Methods**

### **Determination of Physical Constituents of woods**

#### **pH Determination**

The hydrogen ion concentration (pH) of the powdered woods were determined as described elsewhere by Amadi *et al.*, 2004; and TAPPI, 1983, using electrical pH meter PHS-25 made by Life Care England.

### Moisture Content

The moisture content was determined by weighing two grams of each wood powder into a pre-heated, cooled and weighed crucible. The wood sample in each crucible was dried in an oven for 24 hours at a regulated temperature of 85<sup>0</sup>C to a constant weight. Each crucible and its content were cooled in desiccators before weighing in accordance to the method described by Amadi *et al.* (2004).

The moisture content was determined as the percentage moisture, given as:

$$\% \text{ Moisture} = \frac{\text{Weight of wet wood sample} - \text{Weight of oven dry wood sample}}{\text{Weight of oven dry wood sample}} \times 100$$

### Specific Gravity

The specific gravity was determined gravimetrically by measuring the oven-dried wood powder using specific gravity bottle.

### Charring Temperature

The charring temperature was determined by placing 0.50g of each wood powder inside an ignition tube into which a thermometer (0 - 360<sup>0</sup>C) was inserted. The combustion tube was then clamped and heated on a heating mantle regulated at constant heating point. As the materials were heated to char point, the exact char temperatures were recorded.

### Wood Solubility

The wood solubility was determined by placing 1g of each wood powder into nine different 250cm<sup>3</sup> Kjeldahl flasks. 20cm<sup>3</sup> of different solvents, viz: cold water, hot water, 1.0M dilute tetraoxosulphate (VI) acid, 1.0M dilute hydrochloric acid, concentrated tetraoxosulphate (VI) acid, concentrated hydrochloric acid, 1% sodium hydroxide, ether and ethanol were added separately to each wood sample group. The mixture was allowed to stand for 2 hours and the entire mixture in the Kjeldahl flask was boiled gently in a fume cupboard for 1 hour to determine their solubility properties. Distilled water (100 cm<sup>3</sup>) was added to each mixture in the Kjeldahl flask, the solution was filtered through a Whatman filter paper No 42 (125 mm), the residues washed with distilled water, dried in an oven for 3 hours at a regulated temperature of 80 °C, cooled in a desiccator before weighing to determine their final weight and solubility properties.

### Determination of Porosity Index

One gram of cold water starch was prepared with 5cm<sup>3</sup> of water. The starch which serves as an adhesive was mixed with 1.03g of the wood

powder. The mixture (slurry mixture) was moulded into ring shape and allowed to dry on exposure to air for 15 hours. The moulded dry wood sample was weighed using an electronic weighing balance Model B218 and dry weight was determined. The dry wood sample was soaked in 75cm<sup>3</sup> paraffin oil for 24 hours. The soaked dry wood sample was weighed and the weight noted.

Mathematically, Porosity index was calculated thus:

$$\text{Porosity index} = \frac{\text{Weight of dry starch wood sample soaked in oil}}{\text{Weight of dry starch wood sample}}$$

### **Determination of Colour**

The colours of the wood powder were determined using physical visual identification compared with a colour chart. The colours of the wood samples were matched with Chemistry Colour Chart and respective colours were obtained (<http://www.rfs.org.uk/learning/what-wood>).

### **Phytochemical constituents of the wood samples**

The following constituent of various wood samples were determined using standard methods as described by Edeoga *et al.* (2005).

### **Qualitative Analyses of the Phytochemicals of the wood Sample**

#### **Test for Tannins**

Weighed 0.30g of each wood powder was boiled in 30cm<sup>3</sup> of water in a water bath for 10m and then filtered using Whatman filter paper No 42 (125mm). Three drops of 0.1% ferric chloride was added to 5cm<sup>3</sup> of the filtrate and observed for brownish green or a blue black colouration.

#### **Test for Phlobatannins**

Some 30cm<sup>3</sup> of distilled water was added to 0.30g of each wood powder weighed into a beaker. The mixture was allowed to stand for 24 hours. Measured 10cm<sup>3</sup> of the aqueous extract of each wood sample was boiled with 5cm<sup>3</sup> of 1% aqueous hydrochloric acid and observed for deposit of red precipitate.

#### **Test for Saponin**

To 0.30g of the wood powder was added 30cm<sup>3</sup> of distilled water, boiled for 10 minutes in a water bath and filtered using Whatman filter paper No 42 (125mm). The filtrate (10 cm<sup>3</sup>) was mixed with 5cm<sup>3</sup> of distilled water and shaken vigorously for a stable persistent froth. The frothing was mixed with three drops of olive oil and shaken vigorously, then observed for the formation of emulsion.

### **Test for Steroid**

Some 20cm<sup>3</sup> of ethanol was added to 0.30g each wood powder weighed into a beaker, the mixture was allowed to stand for 2 hours. Acetic anhydride (2 cm<sup>3</sup>) was added to 5 cm<sup>3</sup> of the ethanolic extract of each sample following with addition of 2cm<sup>3</sup> of concentrated tetraoxosulphate (VI) acid. The colour changed from violet to blue or green in some samples indicating the presence of steroids.

### **Test for Terpenoids**

Distilled water (30cm<sup>3</sup>) was added to 0.30g of each wood powder weighed into a beaker and the mixture was allowed to stand for 2 hours. Measured 5cm<sup>3</sup> of each extract was mixed in 2cm<sup>3</sup> of chloroform and 3cm<sup>3</sup> of concentrated tetraoxosulphate (VI) acid was added to form a layer. If a reddish brown colouration at the interface was formed, that shows positive results for the presence of terpenoids.

### **Test for Flavonoids** (Sofowara, 1993; Harborne, 1973).

Distilled water (30 cm<sup>3</sup>) was added to 0.30 g of the wood powder weighed into a beaker, the mixture was allowed to stand for 2 hours and filtered using Whatman filter paper No 42 (125mm). Some 5cm<sup>3</sup> of 1.0M dilute ammonia solution was added to 10cm<sup>3</sup> of the aqueous filtrate of each wood extract followed by the addition of 5cm<sup>3</sup> of concentrated tetraoxosulphate (VI) acid. Observation of yellow colouration which disappeared on standing indicates the presence of flavonoids.

### **Test for Alkaloids** (Hikino *et al.*, 1984).

Two grams of each wood powder was placed in a 250 cm<sup>3</sup> conical flask and 20cm<sup>3</sup> of 5% tetraoxosulphate (VI) acid (H<sub>2</sub>SO<sub>4</sub>) in 50% ethanol was added. The mixture was boiled for 2 minutes and filtered through Whatman filter paper No 42 (125 mm). The filtrate was placed in a separating funnel and made alkaline with 5cm<sup>3</sup> of 28% ammonia solution (NH<sub>3</sub>). The solution was extracted with equal volume of chloroform (5.0cm<sup>3</sup>). The chloroform solution was extracted with two 5cm<sup>3</sup> portion of 1.0M dilute tetraoxosulphate (VI) acid, the final acid extract was then used to carry out the following test:-

To 2cm<sup>3</sup> of acid extract was added 0.5cm<sup>3</sup> of Dragendorff's reagent (Bismuth potassium iodide solution) and observed for orange coloured precipitation indicating the presence of alkaloid.

### Test for Glycoside (Hikino *et al.*, 1984).

Some 20cm<sup>3</sup> of water was added to 2.00 g of each wood sample. The mixture was heated on a water bath for 5 minutes and filtered through Gem filter paper (12.5cm). The filtrate was used for the following test:-

- (a) 5cm<sup>3</sup> of the filtrate was added 0.2cm<sup>3</sup> of Fehlings solutions A and B until it turned alkaline (tested with litmus paper) and heated on a water bath for a brick-red colouration.
- (b) Using 15cm<sup>3</sup> of 1.0M sulphuric acid instead of water, the above test was repeated and the amount of precipitate formed compared with that of (a) above. If the precipitate formed is high it indicates the presence of glycoside, if low it indicates the absence of glycoside.

### Quantitative determination of phytochemical constituents of woods

#### Tannin

The Folin-Denis reagent was prepared by dissolving 50g of sodium tungstate (Na<sub>2</sub>WO<sub>4</sub>) in 37cm<sup>3</sup> of distilled water, followed by adding 10g of phosphomolybdic acid (H<sub>3</sub>PMo<sub>12</sub>O<sub>40</sub>) and 25cm<sup>3</sup> of orthophosphoric acid (H<sub>3</sub>PO<sub>4</sub>). The mixture was refluxed for 2 hours, cooled and diluted to 500cm<sup>3</sup> with distilled water. The method used was as reported by Amadi *et al.*, (2004). One gram of each wood powder was weighed into a conical flask and 100 cm<sup>3</sup> of distilled water added. This was boiled gently on an electric hot plate for 1 hour and filtered through Whatman filter paper No 42 (125 mm) into a 100 cm<sup>3</sup> volumetric flask. For colour development, 50cm<sup>3</sup> of distilled water and 10cm<sup>3</sup> of diluted extract (aliquot volume) were pipetted into a 100 cm<sup>3</sup> conical flask, followed by the addition of 5.0cm<sup>3</sup> Folin-Denis reagent and 10cm<sup>3</sup> of saturated Na<sub>2</sub>CO<sub>3</sub> solution.

After thorough mixing, the solution was allowed to stand for 30 minutes in a water bath at a temperature of 25°C. Optical density was measured at 700 nm with the aid of a Spectrum Lab23A spectrophotometer and optical density (absorbance) compared on a standard tannic acid curve. The tannic standard curve was prepared by dissolving 0.20 g of tannic acid in distilled water and diluted to 200 cm<sup>3</sup> mark (1 mg/cm<sup>3</sup>). Varying concentrations (0.2 - 1.0 mg/cm<sup>3</sup>) of the standard tannic acid solution were pipetted into five different test tubes. 5cm<sup>3</sup> of Folin-Denis reagent and 10cm<sup>3</sup> of saturated Na<sub>2</sub>CO<sub>3</sub> solution were pipetted into the test tube, and was made up to the 100 cm<sup>3</sup> mark with distilled water. The solution was left to stand for 30 minutes in a water bath at a temperature of 25°C. Optical density was measured at 700 nm with the aid of a Spectrum Lab23A spectrophotometer. A plot of optical density (absorbance) versus tannic acid concentration was made.

$$Tannic\ acid\ \left(\frac{mg}{100g}\right) = \frac{C \times extract\ volume \times 100}{Aliquot\ volume \times weight\ of\ sample}$$

Where C = concentration of tannic acid read off the graph.

### **Determination of Alkaloids (Harborne, 1973).**

Some 2.50 g of each wood powder was weighed into a 250 cm<sup>3</sup> beaker and 200 cm<sup>3</sup> of 10 % acetic acid in ethanol was added to each wood powder and allowed to stand for 4 hours. This was filtered and the extract was concentrated on a water bath to one - quarter of the original volume followed by addition of 15 drops of concentrated ammonium hydroxide drop wise to the extract until the precipitation was complete. The whole mixture was allowed to settle for 3 hours, the supernatant was discarded and the precipitates washed with 20cm<sup>3</sup> of 0.1M of ammonium hydroxide and then filtered using Gem fitter paper (12.5cm). The residue was dried in an oven and weighed using electronic weighing balance Model B-218.

The percentage of alkaloid can be expressed mathematically as:-

$$\% \text{ Alkaloid} = \frac{\text{Weight of alkaloid}}{\text{Weight of sample}} \times 100$$

### **Determination of flavonoid**

Each wood powder weighing 2.50 g was placed in a 250 cm<sup>3</sup> beaker and 50 cm<sup>3</sup> of 80% aqueous methanol added, covered and allowed to stand for 24 hours at room temperature. The supernatant was discarded and the residue re-extracted three times with the same volume of ethanol. The whole solution of each wood sample was filtered through Whatman filter paper No 42 (125 mm). The filtrate of each wood sample was later transferred into a crucible and evaporated to dryness over a water bath. The crucible and its content was cooled in a desiccator and weighed until constant weight was obtained (Boham and Kocipai- Abyazan, 1994).

The percentage of flavonoid is expressed mathematically as:-

$$\% \text{ Flavonoid} = \frac{\text{Weight of flavonoid}}{\text{Weight of sample}} \times 100$$

### **Determination of Saponin**

Five gram of each wood powder was put into a 250 cm<sup>3</sup> conical flask and 100 cm<sup>3</sup> of 20% aqueous ethanol was added. The mixture was heated over a hot water bath for 4 hours with continuous stirring at a temperature of 55 °C. The mixture was filtered and the residue re-extracted with another 100cm<sup>3</sup> of 20% aqueous ethanol, heated for 4 hours at a constant temperature of 55°C with constant stirring. The combined extract was reduced to 40 cm<sup>3</sup> over water bath at a temperature of 90 °C. The concentrate was transferred into a 250cm<sup>3</sup> separator funnel and 20cm<sup>3</sup> of diethyl ether was added and shaken vigorously. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated twice. 60cm<sup>3</sup> of n-

butanol was added and the butanol extract was washed twice with 10cm<sup>3</sup> of 5 % sodium chloride. The sodium chloride layer was discarded and the remaining solution heated in a water bath for 30 minutes, after which the solution was transferred into a crucible and was dried in an oven to a constant weight (Obdoni and Ochuko, 2001).

The saponin content was calculated as a percentage:

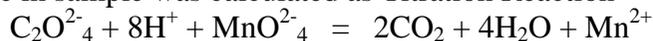
$$\% \text{ Saponin} = \frac{\text{Weight of saponin}}{\text{Weight of sample}} \times 100$$

### Determination of Oxalate

Some 2.50g of each wood powder was weighed into a 250cm<sup>3</sup> beaker and the wood powder extracted three (3) times by warming with 20cm<sup>3</sup> of 0.3M HCl at a temperature of 50°C with constant stirring using a magnetic stirrer for 1 hour.

For oxalate estimation, 5.0 cm<sup>3</sup> of extract was made alkaline by adding 1.0cm<sup>3</sup> of 5M ammonium hydroxide. This was made acidic by adding 2 drops of phenolphthalein indicator, 3 drops of glacial acetic acid and 1.0cm<sup>3</sup> of 5% calcium chloride and the mixture was allowed to stand for 3 hours after which it was then centrifuged at 3000 rpm for 15 minutes. The supernatant was discarded and the precipitate washed three times with hot water by thorough mixing each time followed by centrifugation. Then to each tube, 2.0cm<sup>3</sup> of 3M tetraoxosulphate (VI) acid was added and the precipitate dissolved by warming in a water bath at a temperature of 70 °C. The content of each tube was then titrated with freshly prepared 0.01M potassium permanganate (KMnO<sub>4</sub>) at room temperature until the first pink colour appears throughout the solution. However, when solution was allowed to stand returns to colourless after which it was warmed on an electric hot plate at a temperature of 70 °C for 3 minutes, re-titrated again until a pink colour appears and persists for at least 30 seconds (Munro and Bassir, 1969).

Oxalate in sample was calculated as Titration Reaction



Ratio of reacting ions = 1:1

$$\text{From } M_1V_1 = M_2V_2$$

Where

$M_1$  = molarity of KMnO<sub>4</sub>

$M_2$  = molarity of extract (oxalate)

$V_1$  = Volume of extract (oxalate)

$V_2$  = Volume of KMnO<sub>4</sub> (Titre Value)

Molecular Weight of CaCO<sub>3</sub> = 100

Weight of oxalate in titre =  $M_2 \times \text{molecular weight} = Xg$

$$\text{Weight of oxalate in titrand } 2 \text{ Cm}^3 = \frac{Xg}{1000} \times 2 = Y$$

$$100 \text{ Cm}^3 \text{ of oxalate extract will contain} = \frac{Y}{2.5} \times 100g = W$$

$$\% \text{ oxalate composition g/100g} = \frac{W}{2.5} \times \frac{100}{1}$$

### Determination of Cyanogenic Glycoside

One gram of each dry wood powder was weighed into a 250cm<sup>3</sup> round bottom flask and 200cm<sup>3</sup> of distilled water was added and allowed to stand for 2 hours for autolysis to occur. An antifoaming agent (tannic acid) was added and full distillation carried out in a 250cm<sup>3</sup> conical flask containing 20cm<sup>3</sup> of 2.5% NaOH (sodium hydroxide). To 100cm<sup>3</sup> of each distillate containing cyanogenic glycoside, 8cm<sup>3</sup> of 6M NH<sub>4</sub>OH (ammonium hydroxide) and 2cm<sup>3</sup> of 5% KI (Potassium Iodide) was added, mixed and titrated with 0.02M AgNO<sub>3</sub> (silver nitrate) using a micro-burette against a black background. Permanent turbidity indicates the end point (Amadi *et al.* 2004).

Cyanogenic glycoside content of the sample was calculated as:

$$\text{Cyanogenic glycoside} \left( \frac{\text{mg}}{100\text{g}} \right) = \frac{\text{Titre Value (Cm}^3) \times 1.08 \times \text{exact volume}}{\text{Aliquot volume (Cm}^3) \times \text{sample weight (g)}} \times 100$$

### Result and discussion

Table 1 shows the various timbers indigenous to Niger delta area of Nigeria. Most of them are domiciled in Port Harcourt, Calabar, Ikom, Eket and parts of Rivers state. Here they are mainly used as sources of timbers and their roots and leaves used for medical purposes. Most of these timbers are part of the mangrove rainforest where they constitute good percentage of trees in the niger delta forest vegetation of Nigeria. They have been identified and are well known to timber dealers in Nigeria. Their indigenous names as well as botanical names are written in table 1 below.

Table 1: Names and areas of location of wood /timbers (samples) from Niger Delta Area of Nigeria.

S/N	Wood Sample (Botanical Name)	Botanical families	Igbo Names	Yoruba Names	Hausa Names	Areas of Location
1	<i>Monodora tenuifolia</i>	<i>Annonaceae</i>	Ehuru ofia	Lakesin	Guyiyadanmiya	Port Harcourt
2	<i>Pycnanthus angolensis</i>	<i>Myisticaceae</i>	Akwa-mili	Akomu	Akujaadi	Calabar,
3	<i>Rhizophora racemosa</i>	<i>Rhizophoraceae</i>	Ngala	Eku, eso roro	Loko	Calabar
4	<i>Allanblackia floribunda</i>	<i>Guttiferae</i>	Egba	Orogbo	Guthiferae eku	Calabar, Ikom

5	<i>Glyphaea brevis</i>	<i>Tiliaceae</i>	Anyasu alo	Eso, shishi	Bolukonu kanana	Calabar
6	<i>Cola laurifolia</i>	<i>Sterculiaceae</i>	Ufa	Awori	Karanga	Calabar
7	<i>Bombax brevicuspe</i>	<i>Bombacaceae</i>	Akpudele	Ida odan	Kurya	Ikom
8	<i>Bridelia micrantha</i>	<i>Euphorbiaceae</i>	Ogaofia	Ira odan	Kirni	Calabar, Ikom
9	<i>Lovoa trichiliodes</i>	<i>Meliaceae</i>	Sida	Akoko igbo	Epo-ipa	Calabar
10	<i>Phyllanthus discoideus</i>	<i>Euphorbiaceae</i>	Isinkpi	Ashasha	Baushe	Ikom
11	<i>Sacoglottis gabonensis</i>	<i>Rhizophoraceae</i>	Nche	Atala	Chediya	Rivers
12	<i>Cassipourea barteri</i>	<i>Lecythidaceae</i>	Itobo	Itobo	Odu	Eket
13	<i>Homalinum letestui</i>	<i>Boraginaceae</i>	Akpurukwu	Akpurukwu	-	Ikom, Calabar
14	<i>Khaya ivorensis</i>	<i>Bignoniaceae</i>	Ono	Oganwo	Madachi	Calabar

The significance of the physical properties of wood generally is as means used in placing them into various categories as ways of assessing their usefulness. Some of the uses to which timbers are subjected to include their usefulness in: buildings (houses, doors, bridges, and fences), furniture production and varieties of wood work (carvings, equipment construction such as drums and lorry carriages). The knowledge of their moisture content can help in knowing if they are suitable for various outdoor uses as well as chemical and pharmaceutical application. pH content enable their application in corrosive prone areas. Porosity gives a good estimate of their particle compactness or otherwise and thus shows where they are needed. Colour type is an easy way of identifying them visually. Apart from *Glyphaea brevis* which is neutral with a pH of 7.18, all the wood samples investigated were acidic with *Allanblackia floribunda* having the lowest pH value of 4.53, an indication of being the most acidic. Other woods examined have pH in the range of 5.31 to 6.95. The implication being that the soil in the niger delta environment is suitable for their growth and thus the trees are acidic as a means of adaptability to such environment. It also gave insight into their survivability mainly in the Niger delta region of Nigeria and similar environments in the tropics. The percentage porosity index of the woods are generally low showing that most of them have high compact grain particles suitable for all types of wood uses. Porosity in woods shows empty spaces 'voids' prevalent in them which are normally occupied by water, mineral salts and air, bearing in mind that the wood was formerly part of a live tree where porosity was required for translocation and conduction in vessels. The lowest porosity index was 1.14 % recorded for *Homalinum letestui* while the

highest porosity index was 1.75 % by *Phyllanthus discoideus*. Most wood with higher pore spaces are softwood while those of lower pore spaces are hardwood. The highest specific gravity recorded was 0.54 by *Sacoglottis gabonensis*. These woods generally have good specific gravity which is a measure of their density and weight. According to Panshin and Dezeew (1964), decrease in specific gravity affects the strength of the wood. As specific gravity increases, strength properties increase, because, internal stresses are distributed among more molecular material. Thus it can be deduced that wood with high specific gravity has high wood strength and as such their physical and mechanical properties will not be affected, because, high wood strength increases the physical and mechanical properties of wood. While those with low specific gravity will have low wood strength and their physical and mechanical properties will be affected because of decrease in the wood strength. David *et al.* (1999) explained that specific gravity of wood is based on oven-dry weight of the wood. Thus specific gravity is an excellent index of the amount of wood substance contained in a piece of wood; it is a good index of mechanical properties as long as the wood is clear, straight grained and free from defects. Specific gravity values also reflect the presence of gums, resins and extractives, which contribute little to mechanical properties (David *et al.*, 1999). They have high charring temperatures in the range of 63 – 110 °C. The highest charring temperature of 97 - 110 °C was recorded for *Pycnanthus angolensis* and the least value of 83 °C recorded for *Khaya ivorensis* (Table 2). Since wood charring is a primary factor that determines the load-carrying capacity of structural wood members in a fire, it therefore means that woods with high rate of charring temperature will have high ability of load-carrying capacity than woods of low charring rate. Charring temperatures assists in estimating their usefulness in high temperature environments. The Moisture contents are moderate, of the range 16 % in *Cassipourea barteria* as the lowest and 33 % in *Bombax brevicuspe* being the highest. Most of the woods fall in the moisture content percentage categories of above 20%. This result agrees with the work by Arntzen (1994) in which research discovered that the fibre saturation point usually varies between 21 and 28%. An indication of the pliability of these woods in buildings and various construction works. Moderate water content as seen in table 2 below prevents their breakage and dryness respectively and at the same time improves their strength, showing they are of good quality. Decrease in moisture content can also lead to wood shrinkage and loss of usage/value.

Table 2: Physical properties of the wood samples

S/N	Wood Sample (Botanic names)	pH Values	Moistur e Content (%)	Specifi c Gravit y	Charring Temperatur e (°C)	Porosity index (%)	Colour
1	<i>Monodara tenuifolia</i>	5.85	27.0	0.43	90 – 101	1.38	Cornsilk
2	<i>Pycnanthus angolensis</i>	6.09	25.0	0.36	97 – 110	1.56	Chocolate
3	<i>Rhizophora racemosa</i>	6.25	27.0	0.32	64 – 81	1.32	Tan
4	<i>Allanblackia floribunda</i>	4.53	25.0	0.37	95 – 121	1.23	Cornsilk
5	<i>Glyphaea brevis</i>	7.18	27.0	0.39	94 – 101	1.38	Burly wood
6	<i>Cola laurifolia</i>	6.6	25.0	0.34	64 – 90	1.17	Chocolate
7	<i>Bombax brevicuspe</i>	6.0	33.0	0.23	81 – 92	1.25	Sandy Brown
8	<i>Bridelia micrantha</i>	6.65	29.0	0.23	75 – 95	1.32	Tan
9	<i>Lovoa trichilioides</i>	6.55	26.0	0.19	90 – 115	1.18	Burly Wood
10	<i>Phyllanthus discoideus</i>	6.51	25.0	0.29	92 – 115	1.75	Khaki
11	<i>Sacoglottis gabonensis</i>	6.37	27.0	0.54	89 – 104	1.41	Tan
12	<i>Cassipourea barteria</i>	6.95	16.0	0.44	97 – 114	1.70	Peru
13	<i>Homalinum letestui</i>	6.48	20.0	0.45	65 – 82	1.14	Navajowhit e
14	<i>Khaya ivorensis</i>	5.31	29.0	0.32	63 – 85	1.39	Cornsilk

Table 3 illustrates qualitative presence of phytochemicals present in the woods examined. That though flavanoids are present in all the timber samples examined, they are not heavily present. Also flavanoid has slightly good presence in: *Bombax brevicuspe* and *Bridelia micrantha*, the same could be said of Alkaloids except for *Bridelia micrantha* where alkaloids are absent. Good presence of alkaloid was recorded for *Monodara tenuifolia* and *Cola laurifolia*. *Rhizophora racemosa*, *Bombax brevicuspe*, *Bridelia micrantha*, *Sacoglottis gabonensis* and *Khaya ivorensis* showed heavy presence of tannins. Phloba tannins are present only in *Bridelia micrantha*. Heavy presence of saponin was found in: *Rhizophora racemosa*, *Bombax brevicuspe*, *Sacaglottis gabonensis*, *Khaya ivorensis*. Moreover, *Bridelia micrantha* and *Pycnanthus angolensis* recorded heavy presence of glycoside and terpenoids respectively. Additionally, heavy presence of steroids was found in *Pycnanthus angolensis*, *Allanblackia floribunda*, *Cola laurifolia*, *Lovoa trichilioides*, *Phyllanthus discoideus*, *Cassipourea barteri*, *Homalinum letestui*. The presence and quantity of the phytochemicals in the various woods is as shown on table 3.

Table 3: Result on the qualitative analyses of the phytochemicals of the wood samples

S/N	Wood Sample (Botanic names)	Flavonoids	Alkaloids	Saponins	Tannins	Glycoside	Steroids	Terpenoids	Phloba Tannins
1	<i>Monodara tenuifolia</i>	+	++	+	++	++	++	+	-
2	<i>Pycnanthus angolensis</i>	+	+	+	+	+	+++	+++	-
3	<i>Rhizophora racemosa</i>	+	+	+++	++	++	-	+	-
4	<i>Allanblackia floribunda</i>	+	+	++	+	++	+++	++	-
5	<i>Glyphea brevis</i>	+	+	+	+++	++	+	+	-
6	<i>Cola laurifolia</i>	+	++	+	+++	+	+++	++	-
7	<i>Bombax breviscuspe</i>	++	+	+++	++	-	-	++	-
8	<i>Bridelia micrantha</i>	++	-	+++	+++	+++	++	+	+
9	<i>Lovoa trichiliodes</i>	+	+	+	-	-	+++	+	-
10	<i>Phyllanthus discoideus</i>	+	+	+	-	++	+++	-	-
11	<i>Sacoglottis gabonensis</i>	+	+	+++	+	++	-	+	-
12	<i>Cassipourea barteri</i>	+	+	+	-	++	+++	-	-
13	<i>Homalinum letestui</i>	+	+	+	-	++	+++	-	-
14	<i>Khaya ivorensis</i>	+	+	+++	+	++	-	+	-

Key

Heavily present	.....+++
Slightly present	.....++
Present	.....+
Absent	..... _

Table 4 shows that the wood solubility in the Niger delta timbers are similar to each other. They are insoluble in both cold and hot water, dilute and concentrated HCl, Ethanol, dilute NaOH and diethyl ether. The result as seen in Table 4 indicates that all the woods are slightly soluble in Conc. HCl when heated, and in both concentrated and diluted H<sub>2</sub>SO<sub>4</sub>. They are all soluble in concentrated H<sub>2</sub>SO<sub>4</sub> when heated. The solubility result shows that they are resilient (resistant) to polar, organic and corrosive substances except perhaps highly corrosive hot acids.

Table 4: Result of the solubility property of the wood samples

S/N	Wood Sample (Botanic names)	Hot and cold water	1.0M Dilute HCl	Concentrated HCl	Concentrated HCl + heat	1.0M Dilute H <sub>2</sub> SO <sub>4</sub>	Concentrated H <sub>2</sub> SO <sub>4</sub>	Concentrated H <sub>2</sub> SO <sub>4</sub> + heat	1% NaOH	Ethanol	Diethyl ether
1	Monodora tenuifolia	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble
2	Pycnanthus angolensis	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble
3	Rhizophora racemosa	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble
4	Allanblackia floribunda	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble
5	Glyphaea brevis	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble
6	Cola laurifolia	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble
7	Bombax brevicuspe	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble
8	Bridelia micrantha	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble
9	Lovoa trichilioides	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble
10	Phyllanthus discoideus	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble
11	Sacoglottis gabonensis	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble
12	Cassipourea barteria	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble
13	Homalinum letestui	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble
14	Khaya ivorensis	Insoluble	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Slightly Soluble	Soluble	Insoluble	Insoluble	Insoluble

## Figures of the Quantitative Determination of the phytochemical constituents of the Wood Sample

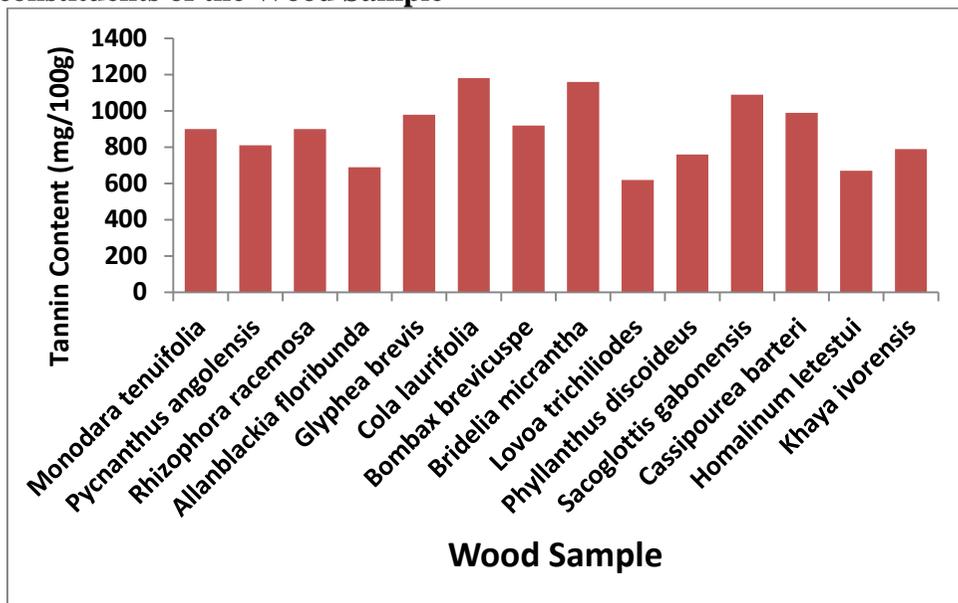


Fig. 1: Quantity of Tannin in Wood Samples

The tannin content in the various woods is shown in fig. 1. The various wood sample examined have appreciable quantities of tannin. *Cola laurifolia* with tannin content of 1180mg/100g and *Bridelia micrantha* having 1160mg/100g of tannin as seen in fig. 1 above, has the highest quantity of tannin. The least content of tannin with value of 620mg/100g was found in *Lovoa trichiliodes*. The range of the quantity of tannin present in the wood samples was between 620 to 1180mg/100g indicating the fact that though the tannin quantity may seem low being a phytochemical, yet, the quantity is appreciable in these Niger delta indigenous timbers. Tannin, also called tannic acid, is any of a group of pale-yellow to light-brown amorphous substances in the form of powder, flakes, or a spongy mass, widely distributed in many species of plants, where they play a role in protection from predation, as pesticides, and in plant growth regulation (Katie and Thornton, 2006). Tannins are classified as ergastic substances, i.e., non-protoplasm materials found in cells. They are also found in leaf, bud, seed, root, and stem tissues. In addition to their principal applications in leather manufacture and dyeing, tannins are used in the clarification of wine and beer, as a constituent to reduce viscosity of drilling mud for oil wells, and in boiler water to prevent scale formation. Because of its styptic and astringent properties, tannin has been used to treat tonsillitis, pharyngitis, hemorrhoids, and skin eruptions; it has been administered internally to check diarrhea and intestinal bleeding and as an antidote for metallic, alkaloidal, and glycosidic

poisons, with which it forms insoluble precipitates. Soluble in water, tannins form dark blue or dark green solutions with iron salts, a property utilized in the manufacture of ink ( <http://www.britannica.com / Ebchecked / topic / 582701 / tannin>). The implication in this study is that those timber among the following samples investigated that have high content of tannin such as *Cola laurifolia* and *Bridelia micrantha*, may have their tannins extracted and used for medical purposes (treatment of tonsillitis, pharyngitis, hemorrhoids, and skin eruptions as well as diarrhea and intestinal bleeding); for commercial usage (protective anti-predator substances, pesticides, plant growth regulator, leather manufacture and dyeing, clarification of wine and beer, anti-viscous agent in drilling mud for oil wells, and in boiler water for the prevention of scale formation). Tannins are dietary anti-nutrients that are responsible for the astringent taste of food and drinks. They are also anti-oxidants.

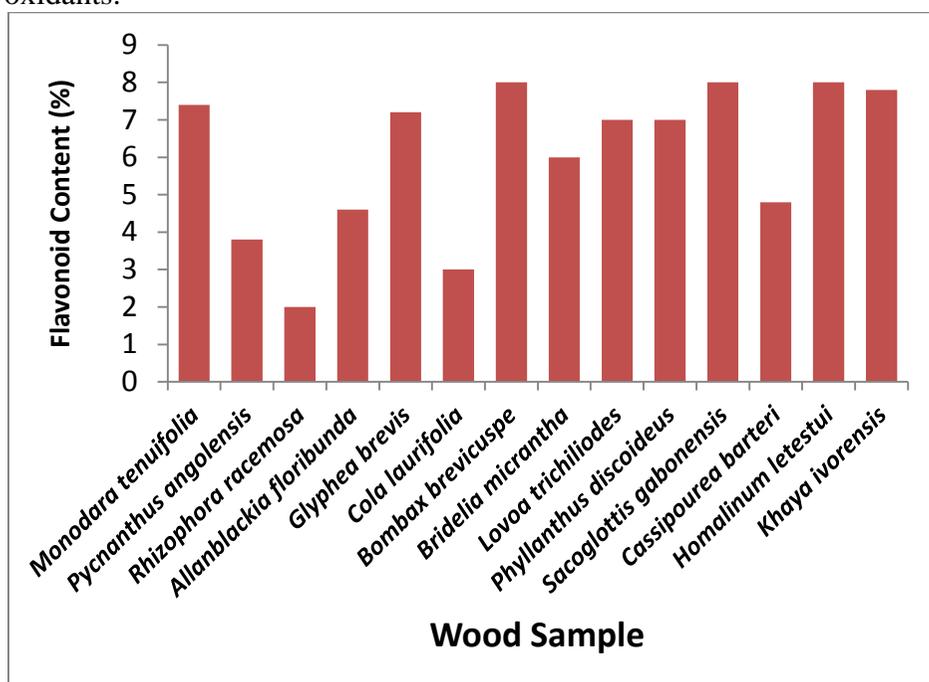


Fig. 2: Quantity of Flavonoid Present in Wood Samples.

Flavonoid content present in most of the wood samples (fig. 2) such as *Homalinum letestui*, *Sacoglottis gabonensis*, *Khaya ivorensis*, *Phyllanthus discoideus*, *Lovoa trichiloides*, *Bridelia micrantha*, *Bombax brevicuspe*, *Glyphea brevis* and *Monodara tenuifolia* were above 6%. This shows that flavonoid content is appreciable in the wood samples investigated. Flavonoids are plant nutrients that when consumed in the form of fruits and vegetables are non-toxic as well as potentially beneficial to the human body (<http://www.wisegeek.com/what-are-flavonoids.htm>). Flavonoids are widely

distributed throughout plants, and together with carotenes are responsible for the colouring of fruits, flowers, vegetables and herbs. They also play a role in protecting the plants from microbes and insect attacks. In higher plants, flavonoids are involved in UV filtration, symbiotic nitrogen fixation and floral pigmentation. More importantly, the consumption of foods containing flavonoids has been linked to numerous health benefits. Though research shows flavonoids alone provide minimal antioxidant benefit due to slow absorption by the body, there is indication that they biologically trigger the production of natural enzymes that fight diseases that reduce the risk of certain cancers, heart disease, and age-related degenerative diseases. Some research also indicates flavonoids may help prevent tooth decay and reduce the occurrence of common ailments such as the flu (<http://www.wisegeek.com/what-are-flavonoids.htm>). Thus the implication of appreciable flavonoid in tibers of niger delta area of Nigeria investigated is that most of these woods, apart from timber usage in which they are currently applied can also be used in health and nutritional industries especially for herbal purposes.

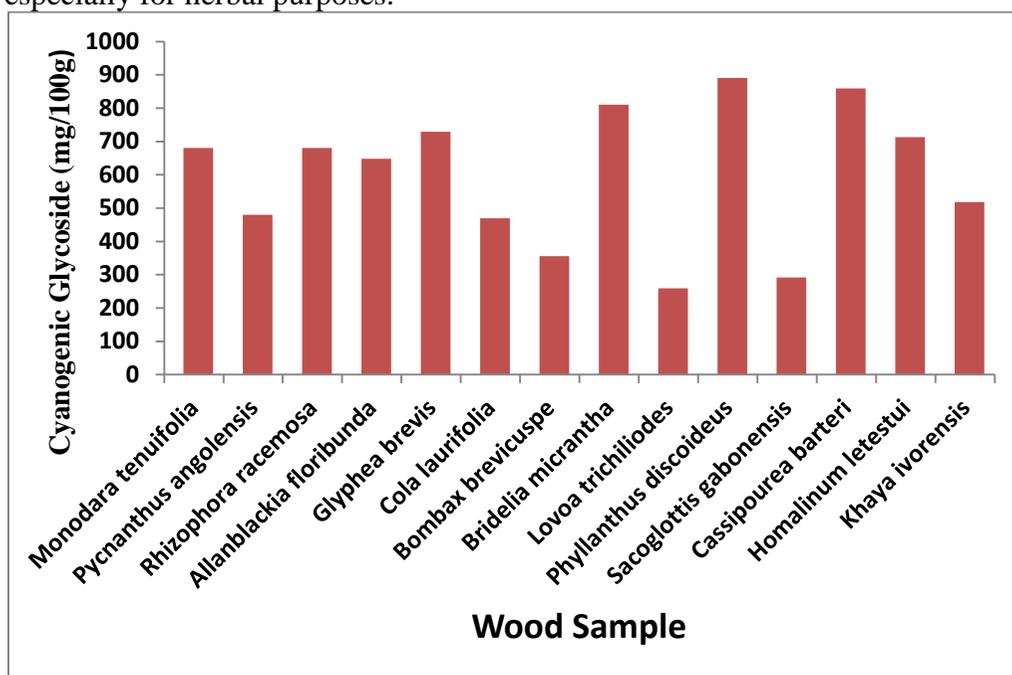


Fig. 3: Quantity of Cyanogenic glycoside present in the wood samples.

In fig. 3, the quantity of cyanogenic glycoside recorded in each of the wood samples was less than 1000 mg/g with the highest contents of 891 mg/g, 859 mg/g and 810 mg/g found in *Phyllanthus discoideus*, *Cassipourea barteri* and *Bridelia micrantha*. Glycosides are compounds containing a carbohydrate and a non-carbohydrate residue in the same molecule. The

carbohydrate residue is attached by an acetal linkage at carbon atom 1 to a non-carbohydrate residue or aglycone. The non-sugar component is known as the aglycone and sugar component glycone. Thus, a glycoside is a molecule in which a sugar is bound to a non-carbohydrate moiety, usually a small organic molecule. In plants, aglycone in cyanogenic glycosides contains a cyanide group which when plants are attacked are released and become activated by enzymes in the cytoplasm. These remove the sugar part of the molecule and release toxic hydrogen cyanide, storing them in inactive forms in the cytoplasm preventing them from damaging the plant under normal conditions. In humans, glycosides increase capillary resistance and decrease vitamin C deficiency. They are recommended in the treatment of thrombopenia (blood coagulation), influenza, fever, gastric ulcer and have cortisone like action in rheumatic arthritis and other inflammatory diseases. Cyanogenic glycosides are anti-nutrient glycosides that contain the cyanide (-CN) group.

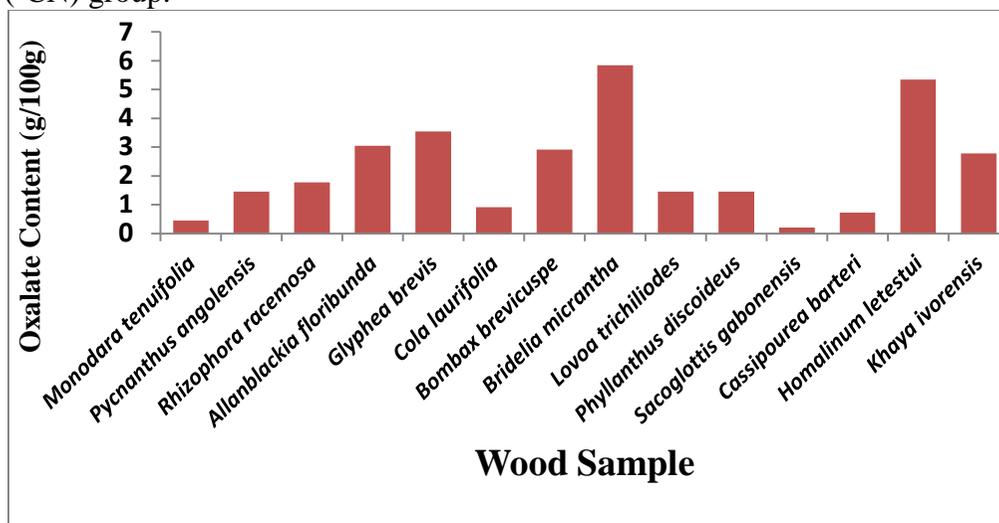


Fig. 4: Quantity of Oxalate present in the wood samples

*Bridelia micrantha* and *Homalinum letestui* with Oxalate content of 5.84 g/100g and 5.34 g/100g respectively contain the highest quantity of this phytochemical among the wood samples analysed in this work. The least Oxalate value of 0.21 g/100g was found in *Sacoglottis gabonensis*. The rest of the result of oxalate content is as shown in fig. 4. The reason for the higher content of oxalate in some of the woods is not known but may be attributed to plants age, season, climate and the soil type (Mahmut, 2000). From literature, foods high in oxalate causes inflammation, pain and burning, irritation of tissues and mucous membranes, and contribute to the formation of calcium oxalate kidney stones (<http://alwayswellwithin.Com/2010/04/27/high-oxalata-foods-can-trigger-pain-and-information>). Oxalates

are dietary anti-nutrients that chelate dietary calcium. Therefore, the lower the rate of oxalates in wood samples as seen above the better for the nutritional and medical properties of the wood.

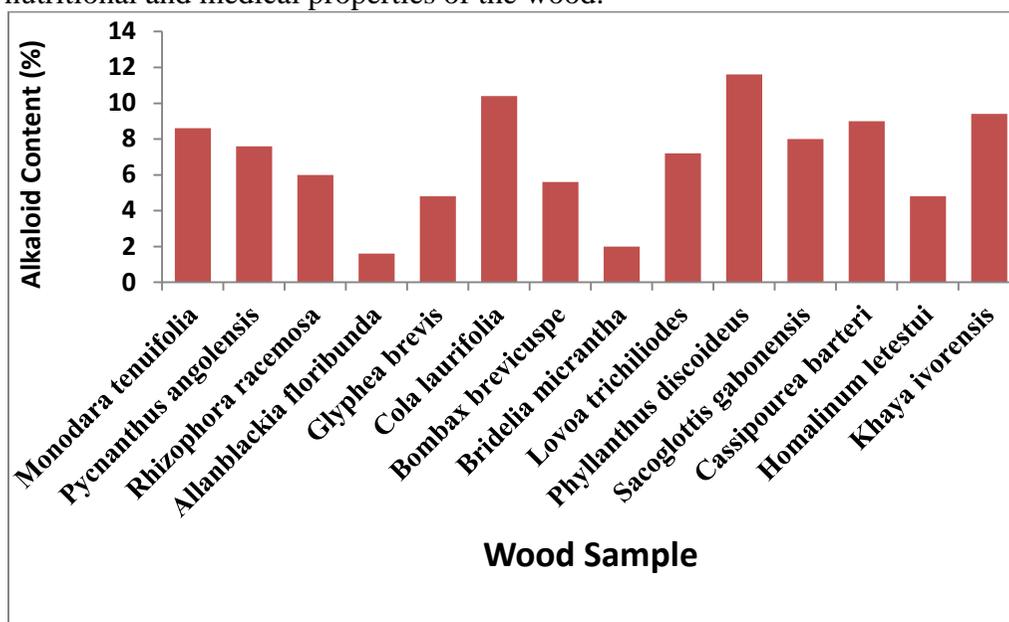


Fig. 5: Quantity of Alkaloid present in Wood Samples.

Fig. 5 is detailed illustration of the content of Alkaloid present in the samples analyzed. In ascending order of alkaloid content, the wood content of same phytochemical is as shown: *Allenblackia floribunda* (1.6%), *Bridelia micrantha* (2.0%), *Glyphea brevis* (4.8%), *Homalinum letestui* (4.8%), *Bombax brevicuspe* (5.6%), *Rhizophora racemosa* (6.0%), *Lovoa trichilioides* (7.2%), *Pycnanthus angolensis* (7.6%), *Sacoglottis gabonensis* (8.0%), *Monodara tenuifolia* (8.6%), *Cassipourea barteri* (9.0%), *Khaya ivorensis* (9.4%), *Cola laurifolia* (10.4%), *Phyllanthus discoideus* (11.6%).

Alkaloids are produced by a large variety of organisms, including bacteria, fungi, plants, and animals, and are part of the group of natural products. In addition to carbon, hydrogen and nitrogen, alkaloids may also contain oxygen, sulphur and more rarely other elements such as chlorine, bromine, and phosphorus. Current research demonstrates not only that alkaloids participate in plant metabolism over the long term, it has been suggested that alkaloids may have a role in the defense of the plant against singlet oxygen, which is damaging to all living organisms and is produced in plant tissues in the presence of light. Of fifteen alkaloids tested, most showed a good ability to quench singlet oxygen, with brucine and strychnine being especially efficient. In human, they often have pharmacological effects and are used as medications, as recreational drugs, or in entheogenic rituals.

Although alkaloids act on a diversity of metabolic systems in humans and other animals, they almost uniformly invoke a bitter taste ([http://www.us.elsevierhealth.com/media/us/sample,chapters / 9780702029332 / 9780702029332\\_2.pdf](http://www.us.elsevierhealth.com/media/us/sample,chapters/9780702029332/9780702029332_2.pdf)).

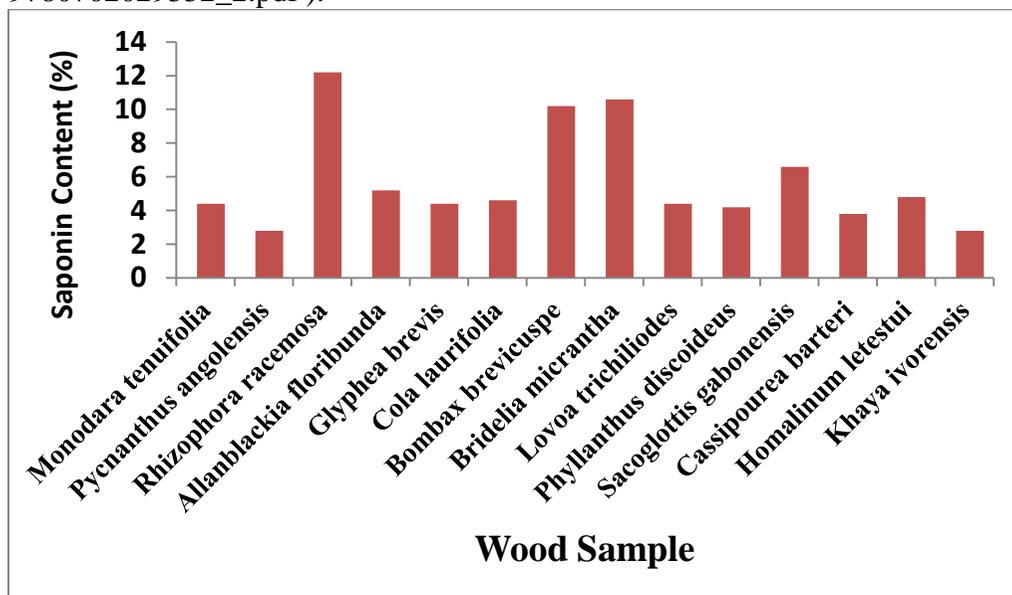


Fig. 6: Quantity of Saponin present in Wood Samples

From the bar chart in fig. 6 of the result of the percentage saponin content of the various Niger delta indigenous timbers examined, the saponin content range is between 2.8 to 12 %. The saponin contents in decreasing order are as follows: *Rhizophora racemosa* (12.2 %), *Bridelia micrantha* (10.6 %), *Bombax brevicuspe* (10.2 %), *Sacoglottis gabonensis* (6.6 %), *Allanblackia floribunda* (5.2 %), *Homalinum letestui* (4.8 %), *Cola laurifolia* (4.6 %), *Monodara tenuifolia* (4.4 %), *Glyphea brevis* (4.4 %), *Lovoa trichiliodes* (4.4 %), *Phyllanthus discoideus* (4.2 %), *Cassipourea barteri* (3.8 %), *Pycnanthus angolensis* (2.8 %), *Khaya ivorensis* (2.8%).

Saponins are basically phytochemicals which are found in most of the herbs, beans and vegetables. They are glycosides with distinctive foaming characteristics. Saponin protects plants against microbes and fungi; they are natural pesticides, as they are good insect repellent. Some plant saponins may enhance nutrient absorption and aid in animal digestion. However, saponins are often bitter to taste, and so can reduce plant palatability. Saponins are found to have numerous health benefits. Recent studies have illustrated saponins effects which have been beneficial on the treatment of allergies, eczema, malaria, and control of blood cholesterol levels, bone health, cancer, and building up of the immune system. ([http://www.herbs2000.com/h\\_menu/saponins.htm](http://www.herbs2000.com/h_menu/saponins.htm)).

## Conclusion

The results of the physical properties and phytochemical constituents of the wood samples from Niger delta area of Nigeria indicated that these phytochemical constituents are present on the wood samples. However, these constituents are more concentrated in some woods than the others. Fig. 1 – 5 clearly illustrates various phytochemical contents in these woods. Some of the benefits derivable from this research as regards these woods showed that tannins can be harnessed for leather, dye, wood adhesives and pharmaceutical industries. The presence of Alkaloids signified the possession of antimicrobial properties within the woods while the presence of flavonoid shows possession of antioxidant, anti- inflammatory and antiviral infection activities. Flavonoids was said to have the ability to lower the cholesterol level. Saponins are found to have numerous health benefits. Recent studies have illustrated saponin effects which have been beneficial on the control of blood cholesterol levels, bone health, cancer, and building up of the immune system. This work is therefore a basis establishing the presence of these phytochemicals in these woods. Thus niger delta timbers can also be used for other purposes (wooden doors, wood works, boat construction, paper production etc) due to their physical qualities, apart from timber usages for construction of house roofs as they are currently employed in Nigeria.

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## References:

- Amadi, B.A., Agomuo, E.N. and Ibegbulem, C.O. Research Methods in Biochemistry. Supreme Publishers, Owerri. pp. 90-115, 2004.
- Akharaiyi, F.C., Boboye, B. and Adetuyi, F.C. Antibacterial, Phytochemical and Antioxidant Activities of the Leaf Extract of *Gliricida sepium* and *Spathodea campanulata*. *World Applied Science Journal*, 16 (4): 523-530, 2012.
- Akindele, S.O. and Lemay, V.M. Development of Tree Volume Equations for Common Timber Species in the Tropical Rain Forest Area of Nigeria, *Journal of Forest Ecology and Management*, 226: 41-48, 2006.
- Arntzen, C.J. (1994). Wood Properties. *Encyclopedia of Agricultural Science*. Fl:Academic Press, Orlando. pp 549-561, 1994.
- Boham, B.A. and Kocipai, A.R. Flavonoids and Condensed Tannins from Leaves of Hawaiian *Vaccinium vaticulatum* and *V. calycinium*. *Pacific Sci.* 48:458-463, 1994.

- Douglas, W.M. America's Forest: A history of resiliency and recovery: *Forest Products Journal*. 45(10) 18 – 28, 1995.
- Compaore, W.R., Nikiema, P.A., Bassole, H.I.N., Savadogo, .A., Movecovcou, J., Hounhouig, D.J. and Traore, S. A. Chemical composition and Antioxidative Properties of Seeds of *Moringa oleifera*, Pulps of *Parkia biglobosa* and *Adansonia digitata* Commonly Used in Food Fortification in Burkina Faso. *Current Research Journal of Biological Sciences* 3(1):64-72, 2011.
- David, W.G., Jerrold, E.W. and David, E.K. Wood Handbook-Wood as an Engineering Material.Gen.Tech. Rep.FSL-GTR-113. Madison, W.I.: U.S. Department of Agricultural Forest Service, Forest Products from Forest Product Laboratory (1999). Laboratory. 463P. pp.2-26. <http://www.woodweb.com/resources/wood-eng-handbook/ch04.pdf>.
- Eboatu, A.N., Altine, A.N. and Abdulraham, F.W. Studies on Thermal Characteristics of Some Common Tropical Timbers. *Journal of Applied polymer science* 44:239-242, 1990.
- Edeoga, H.O., Okwu, D.E. and Mbaebie, B.O. Phytochemical constituents of some Nigerian Medical Plants. *Africa Journal of Biotechnology* 4(7): 685-688, 2005. <http://www.academicjournals.org/AJB>.
- Functions of Alkaloids in Plant.  
<http://www.us.elsevierhealth.com/media/us/samplechapters/9780702029332/9780702029332>. Retrieved 23 January, 2012.
- Fuwape, J.A. Wood Utilization: from Cradle to the Grave, A paper presented at the 25<sup>th</sup> Inaugural Lecture of the Federal University of Technology Akure, Nigeria, p.3, 2000.
- Harborne, J.B. Phytochemical Methods. A Guide to Modern Techniques of Plant Analysis. London: Chapman and Hall, New York, pp 6-466, 1973.
- Hikino, H., Kiso, Y., Wagner, H. and Fiegi, M. Antihepatotoxic Actions of Flavonoids of Flavonoligans. *Planta Medica* 5:248-250, 1984.
- Hogan, M. C. Niger River: Encyclopedia of Earth. (Ed. M. McGinley). National Council for Science and Environment. Washington DC, 2013.
- Katie, E.F. and Thorington, R. W. Squirrels: the Animal Answer Guide. Johns Hopkins University Press, Baltimore. p.91, 2006.
- Key, R.W.J., Onochie, C.F.A. and Stanfield, D.P. Nigerian Trees, Department of Forest Research Publishers, Ibadan Vol 1, pp 38, 61, 68, 81, 93, 103 – 265, 1964.
- Mahmut, C. The Metabolism of Oxalic Acid. *Turkey Journal of Zoology* (24): 103- 106, 2000.
- Munro, A. and Bassir, O. Oxalate in Nigerian Vegetables. *W.A Journal of Biological and Applied Chemistry* 12(1):4-8, 1969.

Obdoni, B.O. and Ochukpo, P.O. Phytochemical Studies and Comparative Efficacy of the Crude Extracts of Some Homostatic Plants in Edo and Delta States of Nigeria. *Global J. Pure & Appl. Sci.* 8(2):203-208, 2001.

Panshin, A.J. and Dezeew, P. Textbook of Wood Technology. Vol. 1. McGraw-Hill, NewYork. p.187, 1964.

Saponins. <http://www.herbs2000.com/h-menu/saponins.htm>. Retrieved 12. March 2012.

Sofowara, A. Medicinal Plants and Traditional Medicine in Africa. Spectrum Books, Ibadan, Nigeria. pp.1-20, 1993.

Tannin.<http://www.britannic.com/EBchecked/topic/582701/tannin>. Retrieved 8 March, 2011.

Technical Association of Pulp and Paper Industry (TAPPI). Cold Extraction Method for Hydrogen Ion Concentration (pH) of Paper Extracts, TAPPI T509om-83, 1983.

What is Wood? <http://www.rfs.org.uk/learning/what-wood>. Retrieved 9 September, 2011.