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Characterisation, Phytochemical and Functional Groups Assay of *Bombax brevicuspe* Stem: A Tropical Timber

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Authors' contributions

This work was carried out in collaboration between all authors. Author IPU designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors CME and ANE managed the analyses of the study. Author HIK managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The elucidation of *Bombax brevicuspe* wood was analysed for thermal and physico-chemical techniques. The results obtained were as follows: afterglow time 253.67 sec, flame duration 113.33 sec, flame propagation rate $20.3x10^{-2}cm.s^{-1}$, ignition time 2.33 sec, thermal conductivity $51.34x10^{2}$Umoh/cm, electrical conductivity $5.3x10^{-3}Sm^{-1}$, ash content 3.4%, moisture content 29.97%, oven dry density $22.3x10^{-2}g.cm^{-3}$, water imbibitions (at different time intervals: 30 mins 46.6%, 5hrs 87.6% and 24 hrs 148.9%), etc, These results showed it to be a good timber suitable for various construction purposes. The elemental analysis obtained through Atomic Absorption Spectrophotometer (AAS) indicated the absence of Ca, as well as the presence of Na, K, Pb, Mg, Zn, As, Cu, Hg and Cd in their decreasing order of magnitude respectively as follows: 1.07%, 0.08%, 0.08%, 0.07%, 0.05%, 0,02%, 0.01%, 0.01% and 0.003%. Thin Layer Chromatographic

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(TLC) analysis gave Retardation factor (Rf) value of 0.62 in the chloroform-methanol extract. The phytochemical screening showed the presence of all the tested secondary metabolites except steroids which indicated its therapeutic ability. Their proportions are indicated thus; saponins (10.2%), tannins (920 Mg/100 g), flavonoids (8.0%), carbohydrates (1.62 Mg/g), proteins (1.55%), glycosides (356 Mg/100 g) and alkaloids (5.6%). The Fourier Transform Infrared (FTIR) and Ultraviolet (UV) spectra suggested that the active compound might be 1,2,3-trisubstituted aromatic compound with C=O, O-H and C=N groups attached. The chemical components analysis showed the presence of cellulose 43%, hemicelluloses 20%, lignin 29% and other constituents in their right proportion. From the results, *Bombax brevicuspe* wood could be used for various construction purposes and it also poses some medicinal ability due to the presence of secondary metabolites.

Keywords: Bombax brevicuspe; tropical timber; thermal characteristics; phytochemical and functional groups.

1. INTRODUCTION

Wood is one of the most important natural and endlessly renewable sources of energy which has a major future role as an environmentally cost-effective alternative to burning fossils fuel. The major role of wood is not only the provision of energy but also the provision of energy-sufficient material for our buildings and many other products. In addition, developing wood cells represents one of the most important sinks for excess atmospheric carbon (iv) oxide, thereby reducing one of the major contributors to global warming [1].

It is the fifth most important product of the world trade. Vast quantities of wood are logged by foresters to provide fuel, fibres (for pulp, paper products and boards) and sawn timbers as commodities [1]. The size of a tree varies with the climate, the depth and type of soil in which it grows [2]. The complex chemical make-up of wood (cellulose, hemicelluloses, lignin and pectins) also makes it an ideal raw material for "ligno-chemical" industry. That could replace the petrochemical industry in providing not only plastic and all kinds of chemical products but also food and textile products [1]. The quality of timber depends on its heat resistance, density, moisture content, and susceptibility to insect attacks, workability, grains, colour, porosity and capacity to take polish and vanish [3]. In Nigeria, over 4600 plant species and 350 timbers have been identified [3,4]

Bombax brevicuspe is a plant that belongs to the *Bombacaceae* family with its common names as silk cotton tree, simal red cotton tree, *bombax* in Chinese also known as mumian meaning tree cotton. It is a tall tree of rainforest, 120 ft high with straight bole and small butresses, deciduous, white petals fragrant and fores as habitat. In Nigeria, its Igbo name is akpudele, awori in yoruba and kurya in Hausa [5,6]. *Bombax* is a genus of mainly tropical trees in a mallow family, they are native to Western Africa, Indian subcontinent, South East Asia, as well as sub-tropical regions of East Asia and Northern Australia, distinguished from the genus *Ceiba* which has white flower [5]. There is dearth of information on the wood of *Bombax brevicuspe,* as a result, some thermal and variable properties, chemical constituents, phytochemical and functional group assay of the wood were investigated.

2. EXPERIMENTAL

2.1 Sample Collection and Identification

Bombax brevicuspe timber used for this work was collected from timber shed at Ikom in Ikom Local Government Area of Cross River State, the southern part of Nigeria. It was identified by timber dealer, forest officer and confirmed by literature [7].

2.2 Sample Preparation

The timbers were dried in an oven at 105oC for 24 hours before the experiments. Some samples were cut in a saw mill into two different shapes and sizes; splints of dimensions 30 x 1.5 x 0.5 cm and cubes of dimensions 2.5 x 2.5 x 2.5 cm. Some were ground into powder and then stored in a covered plastic container for analysis.

3. METHODS

3.1 Solubility Analysis

The sample solubility was determined by placing 1g of the sample powder into nine different 250cm^3 Kjeldahl flasks. 20cm^3 of different solvents which include cold water, hot water, 1.0M dilute tetraoxosulphate (IV) acid, 1.0M dilute hydrochloric acid, concentrated

tetraoxosulphate (IV) acid, concentrated hydrochloric acid, 1% sodium hydroxide, ether and ethanol was added separately to each flask. The mixture was allowed to stand for two hours and later boiled gently in a fume cupboard for one hour, to determine their solubility properties.

3.2 The Thermal and Physical Characteristics

Three oven dry splints of the sample were separately used for the determination of afterglow time, flame duration, flame propagation rate and ignition time. Three 2.5 cm cubes of the sample were separately used for the determination of oven dry density, moisture content, water imbibitions and electrical conductivity while the sample dust was used for the determination of ash content, thermal conductivity, elemental contents, specific gravity, charring temperature and destructive distillation of the wood sample. All were variously deterrmined using American Society for testing and material (ASTM) methods [8,9,10]. At the end of the each analysis, the average obtained values from the three samples were recorded as results.

3.3 The Microelement Composition

In determination of trace metal elements, the method used was atomic absorption spectrophotometer (AAS) model PG 990 manufactured by PG instrument Ltd U.S.A.

3.4 The Phytochemical Compounds

The following secondary metabolites: Resins, steroids, terpenoids, tanins, alkaloids, saponin, flavonoids, glycosides, phlobatannins, carbohydrate and protein were qualitatively and quantitatively determined using the sample dust by the various methods outlined by Harbone [11].

In determining the hydrogen ion concentration (PH), the method outlined by Amadi et al. [12] was used. It was done using electrical PH meter PHS-25 made by Life Care England.

3.5 The Chemical Constituents

Lignins, hemicellulose, cellulose, crude fibre, crude protein, carbohydrate, phenol and destructive distillation of the wood products were quantitatively determined using the sample dust by the various methods outlined by Goering, Vansoest, Oakley and Marzieh [13,14,15].

3.6 The Functional Group Analysis

The TLC, Fourier Transform Infrared and Ultraviolet Spectroscopic methods were used for the determination of functional group present in the sample using the sample chloroform-methanol extracts.

4. RESULTS AND DISCUSSION

4.1 Results

The results obtained are as presented in Tables 1-7.

Table 1. Solubility property of *Bombax brevicuspe*

Solvents	Results
Hot and cold water	Insoluble
1.0M Dilute H_2SO_4	Slightly Soluble
Concentrated H_2SO_4	Slightly Soluble
Concentrated H_2SO_4 + heat	Soluble
1.0M Dilute HCl	Insoluble
Concentrated HCl	Insoluble
Concentrated HCl + heat	Slightly Soluble
1% NaOH	Insoluble
Ethanol	Insoluble
Diethyl ether	Insoluble

Table 2. Thermal and physical characteristics of *Bombax brevicuspe*

Parameters	Units	Results
Afterglow time	Sec	253.67
Flame duration	Sec	113.33
Flame propagation rate	$cm.s^{-1}$	20.3×10^{-2}
Ignition time	Sec	2.33
Over dry density	$g.cm^{-3}$	22.3×10^{-2}
Ash content	%	3.4
Thermal conductivity	Umoh/cm	51.34×10^{2}
Electrical conductivity	Sm^{-1}	5.3×10^{-3}
Moisture content	%	29.97
30 mins water imbibitions	%	46.6
5 hrs Water imbibitions	%	87.6
24 hrs water imbibitions	%	148.9
Specific gravity		0.23
Porosity index	%	1.25
PH		6.0
Charring temperature	℃	81 - 92
Wood charcoal	(g)	2.5
Colour		Sandy brown

Table 3. Micro elemental composition % of *Bombax brevicuspe*

Zinc	0.05
Lead	0.08
Cadmium	0.003
Copper	0.01
Sodium	1.07
Calcium	Nil
Magnesium	0.07
Potassium	0.08
Arsenic	0.02
Mercury	0.01

Table 4. Phytochemical composition of *Bombax brevicuspe*

Class of phytochemical compound	Inference
Alkaloids	++
Flavonoids	++
Resins	+
Saponin	+++
Steroids	-
Terpenoids	++
Tannin	++
Carbohydrate	++
Protein	+
Glycoside	+

Key +++ - *highly present*
++ - *moderately present*
\+ - *slightly present*
\- - *absent*

4.2 Discussion

Table 1, indicated that *Bombax brevicuspe* wood powder was insoluble in hot and cold water, ethanol, sodium hydroxide, diethyl ether, dilute HCl and concentrated HCl. Slight solubility was detected with heated concentrated HCl, diluted H_2SO_4 and concentrated H_2SO_4. The sample only dissolved in a high temperatured concentrated H_2SO_4. This is in-line with Petterson (2007) who stated that woods are highly resistance and non degradedable by chemicals, though the chemicals can extract some extraneous materials from the wood. The solubilty result showed that *Bombax brevicuspe* wood could only dissolve in hot concentrated H_2SO_4 acids.

Table 5. Results of quantitative chemical constituents of *Bombax brevicuspe*

Chemical constituents	Units	Results
Lignins	%	29.0
Hemicellulose	%	20.0
Cellulose	%	43.0
Crude fibre	%	6.2
Crude protein	%	1.55
Carbohydrate	Mg/g	1.62
Phenol	Mg/g	4.46
Tannin	Mg/100g	920
Alkaloids	%	5.6
Flavonoids	%	8.0
Saponins	%	10.2
Oxalate	g/100g	2.92
Total acidity	g/100cm^3	0.33
Cyanogenic glycoside	Mg/100g	356
Lipid	%	6.8
Pyroligneous acid	cm^3	1.75
Wood tar	cm^3	0.2
Wood gas	cm^3	840

Table 6. Thin layer chromatographic characteristics of the extract

Sample	Number of spot	Rf value
Chloroform-methanol extract	1	0.62

Table 7. Fourier Transformed Infrared and Ultraviolet Spectra for *Bombax brevicuspe* Chloroform – methanol extract

Wave number (cm^{-1})	Suspected chromophores
3410.26	O-H stretch for alcohol, phenol and carboxylic acid.
2958.90	C-H stretch for alkanes and aromatics.
2842.20	C-H stretch for alkanes
2511,40	C=N stretch for nitriles
1651.12	C=O stretch for ketones, acid amides and esters.
1408.08	C=C stretch for alkenes and aromatics
1108.14	C-O stretch for alcohols, carboxylic acids and esters
1020.38	C-H deformation bonds for alkyl groups.
λ_{max} 366.50 and 744.50	Indicating highly conjugated trisubstituted aromatic compound

Table 2, showed that *Bombax brevicuspe* wood had low afterglow time of 253.67 sec (less than five minutes) which made it less hazardous in fire situations because it wouldn't glow long enough for rekindle to take place. Its flame duration, flame propagation rate and ignition time values indicated that it can moderately sustain combustion. Water imbibitions values at 30 mins 46.6%, 5 hrs 87.6% and 24 hrs 148% intervals showed the capacity of *Bombax brevicuspe* timber to absorb water over a period of time [16]. The oven dry density which is the best single criterion of strength and ash content values are in line with the ascertain of Desch and Dinwoodie [17] which stated that denser and small ash content timbers are suitable in their use as a source of carbondioxide for internal combustion engine. The ash content value of 3.4% also indicated the presence of some essential mineral elements which is evident in Table 3. The result also showed a high moisture content value of 33.3% which is in-line with Arntzen [18] who stated that, the fiber saturation point usually varies between 21 and 28%. Wood gains and losses moisture as change occurs in the temperature and humidity of the surrounding air. Decrease in moisture content of a wood affects the weight dimensions and strength of the wood and as well affects both the physical and mechanical properties of wood, depending on whether the moisture content is above or below the fiber saturation point. The sample also showed good specific gravity which is a measure of their density and strength. According to Panshin and Dezeeuw [19], increase in specific gravity increases strength properties because internal stresses are distributed among more molecular material. As a result, wood with high specific gravity has high wood strength and high physical and mechanical properties. While those with low specific gravity will have low wood strength and their physical and mechanical properties will be affected too [19]. David et al. [10] explained that specific gravity of wood is based on oven dry weight of the wood and also reflect the presence of gums, resins and extravites which contribute little to mechanical properties.

Wood, a thermally degradable and combustible material has its charring as a primary factor that determines the load-carrying capacity of wood in high temperature environment. *Bombax brevicuspe* with high charring temperature of 81-92℃ has high ability of load-carrying capacity in high temperatured environment. The porosity index result indicated the presence of pore spaces in the wood. Pore spaces are filled with either water or air. Smaller pores tend to be filled with water are referred to as capillary porosity while large pores are typically filled with air and are referred to as non-capillary porosity. The porosity index and water imbibition at different intervals results give good estimate of the sample particle compactness and absorptivity [19]. The results showed that *Bombax brevicuspe* is a hardwood that could be very good for construction and other purposes.

Atomic Absorption Spectrophotometric analysis (Table 3) showed the presence of copper, magnesium and potassium which are involved in body enzymatic activities. Potassium also is necessary for proper functioning of the heart, kidney and muscles. Sodium helps in P^H balance of body fluids while zinc is essential for the activity of DNA polymerases, nucleic acid metabolism and cell division [20,21,22,23], arsenic, lead, mercury and cadmium were also present while calcium was absent.

The phytochemical screening result (Table 4) showed the presence of alkaloids, flavonoids, resins, saponin, terpernoids, tannin, protein, glycosides, carbohydrate and absence of steroid. The medicinal values of medicinal plants lie on these phytocompounds and as such produce definite physiological actions in human body. The alkaloids content showed that it can be used as antimycotics and also in the treatment of stomach pains [15]. It has been reported that Flavonoids exhibit an anti-inflammatory, anti-allergic effects, analgesic and anti-oxidant properties [14]. Saponin has been found to be anti carcinogenic, cholesterol reducer and anti-inflammatory substance. Resins are valued for their chemical properties and associated uses as the product of varnishes, adhesives and food glazing agents. Protein indicated high nutritional value of the extract, therefore can help in physical, mental growth and development [13] Tanins are also reported to exhibit anti-inflammatory, gastritics control, irritating bowel disorders and antimicrobial power which heals wounds and stop bleeding [24]. Terpenoids are associated with anti-cancer and also play a role in traditional and alternative medicine such as aromatherapy, antibacterial and other pharmaceutical functions. Resins are valued for their chemical properties and associated uses as the product of varnishes, adhesives and food glazing agents. The high carbohydrate content of the sample extract showed that it is a good source of energy. Protein indicated high

nutritional value of the extract, therefore can help in physical, mental growth and development [25]. The high protein and carbohydrate contents indicate its potency in animal feed formulation.

From the results obtained from Quantitative Chemical Constituents of *Bombax brevicuspe* (Table 5) the sample contained 22% of lignin, 40% of cellulose, 28% of hemicelluloses, etc which help to confirm that the sample is a hard wood. Lignin contributes 20-25% of hardwood. It is largely responsible for the strength, rigidity of plant and shields carbohydrate polymers from microbial and enzymatic attack. Cellulose, a major chemical component of wood fibre wall, contributes 40-50% of hardwoods dry weight. Hemicellulose is a group of carbohydrate biopolymers that exist in close association with cellulose in the plant cell wall but it is less complex and easily hydrolysable [17,26,18,27]. The destructive distillation of *Bombax brevicuspe* gave rise to four products in the following compositions; wood charcoal (2.5 g), pyroligneous acid (1.75 cm^3), wood tar (0.2 cm^3) and wood gas (840 cm^3). As wood reaches elevated temperatures, the different chemical components undergo the thermal degradation that affects the performance of wood [28]. Crude fiber indicates the level of indigestible component of food. Low crude fiber content shows that the sample has high nutritional value [29]. There depicts low oxalate content (2.92 g/1009) in the analyzed sample. Foods high in oxalate causes inflammation, pain and burning, irritation of tissue and mucous membranes and contribute to the formation of calcium oxalate kidney stones [30]. The high lipid content of 6.80% in *Bombax brevicuspe* wood proves energy storage capacity in the structural component of the sample's cell membrane [31,32,33].

The thin layer chromatography of the extract (Table 6) showed one component with R_f value of 0.62 when chloroform-methanol extract was spotted. The TLC result confirmed its high purity and presence of some components shown in the FTIR and UV results explained below.

The FTIR and UV results of the analysed sample chloroform methanol extract (Table 7) revealed strong absorption at 3410 cm^{-1}, which indicated the presence of alcohols, carboxylic acids and phenols. The absorption at 2958 cm^{-1}, 2511 cm^{-1} and 1651 cm^{-1} showed the presence of alkanes, nitriles, amides and esters. The presence of C=C, C-O and C-H for carbon bond in alkenes and aromatics, keto attached to benzene ring and deformation bonds for alkyl groups were shown by absorption at 1408 cm^{-1}, 1108 cm^{-1} and 1020 cm^{-1} respectively. This suggested that the active compound might be 1,2,3-trisubstituted aromatic compound with C=O, O-H and C=N groups attached.

5. CONCLUSION

It was observed from the results of the various analyses that the wood from *Bombax brevicuspe's* stem could be useful in animal feed formulation, serve as a good material for various construction works, contained some bioactive compounds and be used in the cure and management of various diseases. Moreover, the complex chemical makeup of the timber showed the presence of cellulose, hemicelluloses, lignin and other components in the right proportion which confirmed the efficacy of *Bombax brevicuspe* stem as a tropical timber.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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