THE EFFICACY OF *Rhizophora racemosa* WOOD: AN IMPORTANT STUDY

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Abstract: The elucidation of *Rhizophora racemosa* wood was analysed for thermal, chemical, physical and variable techniques. The results obtained were as follows: afterglow time 115.67sec, flame duration 260sec, flame propagation rate $9.7x10^{-2}$ $cm.s^{-1}$, ignition time 4sec, thermal conductivity $16.79x10^{2}$ Umoh/cm, electrical conductivity $4.2x10^{-3}$ Sm^{-1}, ash content 1.11%, moisture content 33.59%, oven dry density $37.9x10^{-2}$ $g.cm^{-3}$, water imbibitions (at different time intervals: 30 min 30.2%, 5 h 59.8% and 24 h 102.2%), etc, These results showed it to serve as a good timber suitable for various construction purposes. The elemental analysis obtained through Atomic Absorption Spectrophotometer (AAS) indicated the absence of Cd, as well as the presence of Hg, Cu, Ca, Zn, Mg, K, As, Pb and Na in their increasing order of magnitude, respectively as follows: 0.001, 0.023, 0.01, 0.016, 0.20, 0,29, 0.38, 0.45 and 1.33%. The Thin Layer Chromatographic (TLC) analysis of the chloroform and chloroform-methanol extracts which gave three spots with Retardation factor (Rf) values of 0.5, 0.7 and 0.5 was further characterized using Fourier Transform Infrared (FTIR) and Ultraviolet (UV) spectroscopic methods . The FTIR and 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 phytochemical screening showed the presence of all the tested secondary metabolites which indicated its therapeutic ability. Their proportions are indicated thus; saponins (12.2%), tannins (900 Mg/100g), flavonoids (2.0%), carbohydrates (1.29 Mg/g), proteins (4.66%), glycosides (680 Mg/100g) and alkaloids (6.0%). The chemical components analysis showed the presence of cellulose 41%, hemicelluloses 28%, lignin 24% and other constituents in their right proportion. The results provided the required information on the properties of *Rhizophora racemosa* wood. It also confirmed the efficacy of the wood for various construction purposes and its medicinal ability due to the presence of the secondary metabolites.

Keywords: *Rhizophora racemosa* thermal characteristics, phytochemical, thin layer chromatography

Introduction

Wood 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. 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 (Christophe, 2002). Timber is a type of wood that has been processed into beams and planks used for structural purposes and, many other uses as well. Trees provide a huge variety of products for humanity. However, it is their timber that provides the greatest contribution in terms of income (Arntzen, 1994). Different trees species provide timber with varying strength, durability, resonance, colour and scent. As a result, only certain tree species are suitable for a given purpose or end use, be it for building materials, veneers, furniture, musical instruments, and others (Eboatu and Altine 1991). 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. In Nigeria, over 4600 plant species and 350 timbers have been identified (Akindele, 2006).

Rhizophora racemosa is a species of mangrove tree in the family Rhizophoraceae. It has a patchy distribution on the Pacific coast of Central and South America, occurs in places on the Atlantic coast of that continent, and has a more widespread range on the Atlantic coast of West Africa (Ellison *et al*., 2010). In West Africa, estuaries, bays and lagoons are fringed by tidal mangrove forests, dominated by *Rhizophora* and *Avicennia*. When new mudflats are formed, seagrasses are the first plants that grow on the mud, with *Rhizophora racemosa*, a pioneering species, being the first mangrove to appear. With time, the mud solidifies and more tree and plant species arrive. On the seaward side the trees are short but get steadily taller further inland (Hughes, 1992). *R. racemosa* is largely wind-pollinated. The fruit produce propagules which may fall into the water and be dispersed by wind and currents (Ngeve *et al*., 2016). In West Africa, *Rhizophora racemosa* is used for construction of poles and firewood on a limited scale. The smoke has antimicrobial properties and is also used for smoking meat. In the Americas it is less likely to be harvested as it is more scarce and is not considered to be of much value (Ellison *et al*., 2010).

Rhizophora racemosa is a reddish and very hard wood. Some of the local names for it are as follows: Yoruba: Ogba; Edo; Odonowe; Itsekiri; Odo; Urhobo: Urhe Nwerim; Ijaw: Agala; Igbo: ngala (Arbonnier, 2004; Udeozo *et al*., 2011). There is dearth of information on the wood of *Rhizophora racemosa*, as a result, some thermal and variable properties, chemical constituents, phytochemical and functional group assay of the wood were investigated.

Materials and Methods

Sample collection and identification

Rhizophora racemosa wood was collected from timber shed at Calabar, Cross River State. Timber dealer, forest officer as well as literature (Keay *et al.,* 1989) helped in the timber identification.

Sample preparation

Rhizophora racemosa timber was cut in a saw mill into two different shapes and sizes; dust from the timber was also collected. The timber was cut into splints of dimensions 30 x 1.5 x 0.5 cm and cubes of dimensions 2.5 x 2.5 x 2.5 cm. The samples were dried in an oven at 105°C for 24 h before the experiments.

Methods

Characterization of thermal properties: Afterglow time, flame duration, flame propagation, ignition time, oven dry density, moisture content, water imbibitions, ash percentage, specific gravity, porosity index, thermal conductivity and electrical conductivity were variously determined using American Society for testing and material (ASTM) methods (1998 & 1999) and as described by Eboatu and Altine (1991). Each experiment was repeated three times and the results averaged. The microelement composition was analysed using atomic absorption spectrophotometer model PG 990 manufactured by PG instrument Ltd USA.

Characterization of phytochemical constituents: resins, steroids, terpenoids, tanins, alkaloids, saponin, flavonoids, glycosides, phlobatannins, carbohydrate and protein were qualitatively and quantitatively determined by the methods outlined by Harbon (1998).

The hydrogen ion concentration (PH) was determined by the method outlined by Amadi *et al.* (2004) using electrical PH meter PHS-25 made by Life Care England.

Characterization of chemical constituents: lignins, hemicellulose, cellulose, crude fibre, crude protein, carbohydrate, phenol and destructive distillation of the wood products were quantitatively determined by the methods outlined by Goering, Vansoest (1975), Oakley (1984) and Marzie (2010). The chloroform-methanol and chloroform extracts were monitored using TLC, Fourier Transform Infrared and Ultraviolet Spectroscopic methods.

Results and Discussion

The results of the solubility, physical, thermal investigations and the analysis of the active constituents present in the wood extract of *Rhizophora racemosa* are given in Tables 1 – 9.

The solubility analysis showed that *Rhizophora racemosa* powder completely dissolved only in the presence of heated concentrated tetraoxosulphate (vi) acid. Therefore, the sample is resistant to polar, organic and corrosive substances except highly corrosive hot acid. This is in line with Petterson (2007) who stated that chemicals are able to extract some extraneous materials in wood, yet woods are highly resistant to them and as such cannot be degraded by the chemicals.

Table 1: Solubility property of *Rhizophora racemosa* species

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

Table 2: Thermal and physical characteristics of *Rhizophora racemosa* species

Characteristics	Units	Results
Afterglow time	Sec	115.67
Flame duration	Sec	260
Flame propagation rate	$cm.s^{-1}$	9.7×10^{-2}
Ignition time	Sec	4
Over dry density	$g.cm^{-3}$	37.9×10^{-2}
Moisture content	%	33.59
30 mins Water imbibitions	%	30 .2
5 hrs Water imbibitions	%	59 .8
24 hrs Water imbibitions	%	102.2
Ash Content	%	1.11
Thermal conductivity	Umoh/cm	16.79×10^{2}
Electrical Conductivity	Sm^{-1}	4.2×10^{-3}
Specific Gravity		0.32
Porosity Index	%	1.32
PH		6.25
Colour		Tan

Thermal characteristics analysis showed that it had high flame duration value of 260 seconds which indicated that it could sustain itself till the whole length of wood got burnt. Afterglow time value of less than four minutes (115.67seconds) showed that it would not glow long enough for rekindle to take place as a result would be less hazardous in fire situations. A Flame propagation rate value of less than 0.28 $cm.s^{-1}$ indicated that the timber is fire-tolerant. Water imbibitions at 30 min, 5 and 24 h intervals with respective values of 30.2, 59.8 and 102.2% showed the capacity of *Rhizophora racemosa* wood to absorb water over a period of time (Udeozo *et al.*, 2014). The oven dry density and ash content values are in line with the ascertain of Desch and Dinwoodie (1981) which stated that dense and small ash content timbers are suitable in their use as a source of carbondioxide for internal combustion engine. The result indicated that *Rhizophora racemosa* is a hardwood that will be very good for construction and other purposes.

Phytochemical analysis revealed the presence of all the tested secondary metabolites which includes; flavonoids, alkaloids, saponin, protein, tannin, steroids, terpenoids, glycosides and carbohydrate. The medicinal values of medicinal plants lie on these phytocompounds which produce definite physicological actions in human body. Flavonoids exhibit an anti-inflammatory, anti-allergic effects, analgesic and anti-oxidant properties (Dunguid *et al.*, 1989). The presence of alkaloids showed that it can be used as antimycotics and also in the treatment of stomach pains (Akpuaka, 2009). Saponin has been found to be anti carcinogenic, cholesterol reducer and anti-inflammatory substance. Tanins are anti-inflammatory, control gastritics and irritating bowel disorders, they also contribute to antimicrobial power which heals wounds and stop bleeding (Gills, 1992). Steroids are used in medicine for treatment of diseases. Terpenoids are associated with anti-cancer and also play a role in traditional and alternative medicine such as aromatherapy, antibacterial and other pharmaceutical functions. Protein indicated high nutritional value of the extract, therefore can help in physical and mental growth and development (Dunguid *et al*., 1989).

Table 3: Phytochemical composition of *Rhizophora racemosa* species

Class of phytocompounds	Inference
Saponin	+++
Flavonoids	++
Steroids	+
Terpenoids	+
Tannin	++
Alkaloids	++
Carbohydrate	++
Protein	+++
Glycosides	++

+++ = highly present; ++ = moderately present; + = slightly present; – = absent

Table 4: Micro elemental composition % of *Rhizophora racemosa* species

Parameter	Result
Zinc	0.16
Lead	0.45
Cadmium	Nil
Copper	0.023
Sodium	1.33
Calcium	0.01
Magnesium	0.20
Potassium	0.29
Arsenic	0.38
Mercury	0.001`

Atomic Absorption Spectrophometric analysis of the sample showed the presence of sodium, potassium, calcium, magnesium, copper and zinc which are beneficial to healthy adults at normal intake levels. Sodium and potassium play important role in maintenance of osmotic, electrolytic balance and proper rhythm of clothing (Tahir *et al*., 1999). Magnesium is for signaling the nervous system and also participates in osmotic and electrolyte balance but can cause genetic disorder (Konrad and Weber, 2003). Copper is also involved in body enzymatic activities while zinc is required for growth, sexual development, wound healing infection, sense of taste and night vision in human (Maret and Sandstead, 2006). Lead, arsenic and mercury were also present while cadmium was absent.

Table 5: Quantitative chemical constituents of *Rhizophora racemosa* species

Chemical constituents	Units	Results
Lignins	%	24.0
Hemicellulose	%	28.0
Cellulose	%	41.0
Crude Fibre	%	1.9
Crude Protein	%	4.66
Carbohydrate	Mg/g	1.29
Phenol	Mg/g	1.02
Tannin	Mg/100g	900
Alkaloids	%	6.2
Flavonoids	%	2.0
Saponins	%	12.2
Oxalate	g/100g	1.78
Total Acidity	$g/100cm^3$	0.03
Cyanogenic Glycoside	Mg/100g	680
Lipid	%	9.6
Wood Charcoal	(g)	5.1
Pyroligneous acid	cm^3	1.3
Wood tar	cm^3	0.2
Wood gas	cm^3	701

Table 6: Thin layer chromatographic characteristics of *Rhizophora racemosa* timber extract

Sample	Number of spot	Rf value
Chloroform-methanol extract	1	0.5
Chloroform extract	2	0.5 & 0.7

Quantitative Chemical Constituents of *Rhizophora racemosa* depicted that the sample contained 24% of lignin, 41% of cellulose, 28% of hemicelluloses and other parameters which help to confirm that the sample is a hard wood. Lignin is largely responsible for the strength, rigidity of plant and shields carbohydrate polymers from microbial and enzymatic attack. It contributes 20 – 25% of hardwood. 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. It contributes 25-35% of hardwood dry weight (Arntzen, 1994; Desch and Dinwoodie 1996). The destructive distillation of *Rhizophora racemosa* gave rise to four products in the following compositions; wood charcoal (5.1 g), pyroligneous acid (1.3 cm^3), wood tar (0.2 cm^3) and wood gas (701 cm^3). As wood reaches elevated temperatures, the different chemical components undergo the thermal degradation that affects the performance of wood. The extent of the changes depends on the temperature level and length of time exposed (White and Dietenberger, 2001).

The thin layer chromatography of the chloroform-methanol and chloroform extracts showed three components with R_f values of 0.5, 0.5 and 0.7. The TLC results confirmed the presence of some components and its high purity.

Tables 7: Fourier transformed infrared and ultraviolet spectra of chloroform 1st spot extract

Wave number (cm^{-1})	Suspected chromophores
4002.43	Free O-H stretch for water
3417.98	O-H stretch for alcohols, phenols and carboxylic acid
2852.81	C-H stretch for alkanes and aromatics
2518.15	C=N stretch for nitriles
1647.26	C = O stretch for ketones, carboxylic acid, amides & esters
1458.83	C=C stretch for alkene and aromatic rings
1019.41	C–O stretch for alcohols, esters and carboxylic acids
461.92	C–H deformation bonds for alkyl groups
UV λ_{max} 223.50, 326.00, 604.50 and 739.50	Indicating highly conjugated trisubstituted aromatic compound

Table 8: Fourier transformed infrared and ultraviolet spectra of chloroform 2nd spot extract

Wave number (cm^{-1})	Suspected chromophores
3403.51	N–H stretch for amines
2843.17	C–H stretch for alkanes and aromatics
2513.33	C=N stretch for nitriles
2133.34	C=C stretch for alkenes
1652.09	C=O stretch for ketones, acid amides and esters
1416.76	C=C stretch for alkene and aromatics
1109.11	C-O stretch for esters
1026.34	C–H deformation bonds for alkyl groups
UV λ_{max} 240.00, 288.50, 604.00 and 745.50	Indicating highly conjugated trisubstituted aromatic compound

Table 9: Fourier transformed infrared and ultraviolet spectra for *Rhizophora racemosa* chloroform - methanol extract

Wave number (cm^{-1})	Suspected chromophores
4413.28	Free O-H stretch
3410.26	O – H stretch for alcohols and phenols
2956.97	C – H stretch for alkanes and aromatics
2514.30	C = N stretch for nitriles
2134.31	C = C stretch for alkenes
1650.16	C = O stretch for ketones, acid amides & esters
1417.73	C = C stretch for alkenes and aromatics
1120.68	C – O stretch for alcohols and phenols
1021.34	C – H deformation bond for alkyl and methyl groups
UV λ_{max} 319.00 and 658.00	Indicating highly conjugated conjugated aromatic amide

From the FTIR and UV spectra of the isolated compounds, the bands observed are summarized in Tables 7 – 9. The O-H stretching bands at 3417.98 and 3410.26 cm^{-1} are of alcohols, carboxylic acid and phenols. The O–H can be said to be associated. The C-H stretching at 2852.81, 2843.17 and 2956.97 cm^{-1} corresponds to that of an aliphatic C–H. The C=N absorption peak for nitriles appeared at 2518.15 m^{-1}, 2513.33 and 2514.30 cm^{-1}. The C=O stretching bands at 1647.26, 1652.09 and 1650.16 cm^{-1} are that of ketones, acid amides, esters and carboxylic acids. The C-O absorption peak for alcohols, esters and carboxylic acids appeared at 1019.41, 1109.11 and 1120.68 cm^{-1} while the C-H deformation bonds for alkyl groups occurred at 461.92, 1026.34 and 1024.34 cm^{-1}. The absorption in the ultraviolet visible spectra and FTIR spectra suggested that the active compound might be 1,2,3-trisubstituted aromatic compound with O–H, C=O, and C=N groups attached.

Conclusion

The results of thermal characteristics, phytochemical and AAS analysis of the woods of *Rhizophora racemosa* had confirmed that it contain some components of medical value and as well as good material for various construction works. The UV and IR spectra show that it contains some bioactive compounds. Phenol represented in IR and UV spectra confirmed the presence of tannins and therefore, the plant can give instant relief when applied on burns or injured skins among other numerous uses. The presence of flavonoids, Ca and Mg from AAS analysis confirmed its anti-inflammatory and anti-oxidant effect. Moreover, the complex chemical makeup of the wood showed the presence of cellulose, hemicelluloses, lignin and other components in the right proportion which confirmed *Rhizophora racemosa* as a fire resistant hardwood and its efficacy as a tropical timber. It is recommended that the anti-microbial properties of the wood extracts be elucidated.

Conflict of Interest

Authors declare that there are no conflicts of interest.

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