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Characterisation, Phytochemical and Functional Groups Assay of *Erythrophleum ivorense Stem* as a Tropical Timber

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ABSTRACT

The elucidation of *Erythrophleum Ivorense* wood was carried out in terms of thermal and physico-chemical techniques. Various physical and thermal test performed on the timber which includes: oven dry density, water imbibitions (at different time intervals: 30mins, 5hrs and 24hrs), afterglow time, flame duration, flame propagation rate, ignition time, thermal conductivity, electrical conductivity, moisture content, ash content etc, showed it to be a good timber suitable for various construction purposes. The AAS result indicated the absence of Cd and Hg, as well as the presence of Na, K, Pb, Ca, Zn, Mg, As and Cu in the decreasing order of their concentrations. TLC analysis gave Rf values of 0.68 and 0.69 in the chloroform and chloroform-methanol extracts respectively. The phytochemical screening showed the presence of all the tested secondary metabolites which indicated its therapeutic ability. The Fourier Transform Infrared and Ultraviolet 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, hemicelluloses, lignin and other constituents in their right proportion. The results confirmed the efficiency of the wood for various construction purposes and its medicinal ability due to the presence of the secondary metabolites.

Keywords: *Erythrophleum Ivorense*, Tropical timber, Thermal characteristics, Phytochemical and Functional groups.

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 [1]. 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.

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 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] and [4]

Erythrophleum ivorense is an evergreen tree that can grow up to 40 metres tall. The bole is cylindrical, but sometimes fluted at the base, 60 - 90cm in diameter, and can be with or without buttresses. The tree is harvested from the wild for local medicinal use and also for its very durable timber, which is traded internationally. The bark, which is traded locally as 'sassy-bark', 'mancona bark', casca bark' or 'écorce de tali' has several medicinal uses which includes fish poison. The sawdust may irritate mucous membranes and may cause allergy and asthma of labourers in sawmills. It is essentially a scattered, canopy tree of old secondary forests, it can also be found in evergreen primary and secondary forests, as well as in moist semi-deciduous forest.

Erythrophleum ivorense is a genus of mainly tropical trees which ranges in West tropical Africa - Gambia to Cameroon, Central African Republic and Gabon. In Nigeria, its Igbo name is inyi, erun in yoruba and idon zakara in Hausa.[5] and [6] For cultivation, it grows well in a sunny position. This species has a symbiotic relationship with certain soil bacteria, these bacteria form nodules on the roots and fix atmospheric nitrogen. Some of this nitrogen is utilized by the growing plant but some can also be used by other plants growing nearby. The bark decoction when added to fermenting palm wine would make it a more potent drink and is also applied externally to relieve pain. A bark extract is taken orally as an emetic and laxative. Water, in which the bark of young branches is crushed, is rubbed on the skin to treat smallpox. The plant is a source of alkaloids. The bark contains the alkaloids cassaine, cassaidine and erythrophleguine. The alkaloid content ranges from 0.2% to 1.1%. In high doses, the bark extract is an extremely strong, rapid-acting cardiac poison, in warm-blooded animals causing shortness of breath, seizures and cardiac arrest in a few minutes. The bark is also used for tanning. The wood is suitable for joinery, heavy flooring, railway sleepers, harbour and dock work, turnery, construction and bridges. It is also used for boat building and wheel hubs. It is a good fuel and makes excellent charcoal.[5]. There is dearth of information on the thermal and variable properties of *Erythrophleum Ivorense* wood, and hence it is important to investigate some properties, chemical constituents, phytochemical and functional group assay of the wood, thereby improving on the search for the

efficacy of the wood as regards its use for various purposes.

EXPERIMENTAL

Sample collection and Identification

Erythrophleum Ivorense timber was collected from timber shed at Ogoja in Ikom Local Government Area of Cross River State. Timber dealer, forest officer (Mr. Vin Okakpu of Nnewi Forestry) as well as literature,[7] helped in the timber identification.

Sample preparation.

Some of the timber samples were cut in a saw mill into two different shapes and sizes; splints of dimensions 30 x 1.5 x 0.5cm and cubes of dimensions 2.5 x 2.5 x 2.5cm. Dust from the timber was also collected and stored in a covered plastic container for analysis. The samples were dried in an oven at 105°C for 24 hours before the experiments.

METHODS

The Thermal and microelemental characteristics: The Afterglow time, flame duration, flame propagation, ignition time, oven dry density, moisture content, water imbibitions, ash percentage, thermal conductivity and electrical conductivity were variously determined using American Society for testing and material (ASTM) methods[8],[9],[10]. The microelement composition was analysed using atomic absorption spectrophotometer model PG 990 manufactured by PG instrument Ltd U.S.A.

The Phytochemical Compounds: resins, steroids, terpenoids, tanins, alkaloids, saponin, flavonoids, glycosides, phlobatannins, carbohydrate and protein were qualitatively and quantitatively determined by the methods outlined by Harbone [11].

The hydrogen ion concentration (PH) was determine by the method outlined by Amadi *et al.*[12] using electrical PH meter PHS-25 made by Life Care England.

The 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, Oakley and Marzieh[13],[14] and [15]

The Functional Group Analysis: The sample chloroform and chloroform-methanol extracts were monitored using TLC, Fourier Transform Infrared and Ultraviolet Spectroscopic methods.

RESULTS AND DISCUSSION

RESULTS

The results of the thermal investigation and the analysis of the active constituents present in the timber extract of *Erythrophleum Ivorense* are given in tables 1- 8.

Table 1: Results of the Solubility Property of *Erythrophleum Ivorense*

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: Results of thermal characteristics of *Erythrophleum Ivorense*

Characteristics	Units	Results
Afterglow time	Sec	0.00
Flame duration	Sec	441.33
Flame propagation rate	$cm.5^{-1}$	0.8×10^{-2}
Ignition time	Sec	6.33
Over dry density	$g.cm^{-3}$	108.7×10^{-2}
Moisture content	%	9.27
30 mins Water imbibitions	%	7.2
5 hrs Water imbibitions	%	10.0
24 hrs Water imbibitions	%	15.4
Ash Content	%	0.28
Thermal conductivity	Umoh/cm	4.43×10^{2}
Electrical Conductivity	Sm^{-1}	8.0×10^{-3}
Specific Gravity		0.34
Porosity Index	%	1.66
PH		5.92
Charring Temperature	°C	70 – 81
Colour		Wheat

Table 3: Micro elemental composition % of *Erythrophleum Ivorense*

Zinc	**0.36**
Lead	1.14
Cadmium	Nil
Copper	0.04
Sodium	0.69
Calcium	0.07l
Magnesium	Nil
Potassium	1.36
Arsenic	0.92
Mercury	Nil

Table 4: Phytochemical composition of *Erythrophleum Ivorense*

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

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

Table 5: Results of Quantitative Chemical Constituents of *Erythrophleum Ivorense*

Chemical Constituents	Units	Results
Lignins	%	25.0
Hemicellulose	%	23.6
Cellulose	%	42.0
Crude Fibre	%	3.9
Crude Protein	%	5.44
Carbohydrate	Mg/g	1.39
Phenol	Mg/g	2.14
Tannin	Mg/100g	800
Alkaloids	%	8.0
Flavonoids	%	8.0
Saponins	%	2.0
Oxalate	g/100g	0.92
Total Acidity	g/100cm^3	0.35
Cyanogenic Glycoside	Mg/100g	891
Lipid	%	0.8
Wood Charcoal	(g)	2.0
Pyroligneous acid	cm^3	2.5
Wood tar	cm^3	0.25
Wood gas	cm^3	926

Table 6: Results of Thin layer chromatographic characteristics Extract of *Erythrophleum Ivorense*

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Sample	Number of spot	Rf value
Chloroform-methanol extract.	1	0.69
Chloroform extract	1	0.68

Table 7: Result of Fourier Transformed Infrared and Ultraviolet Spectra for *Erythrophleum Ivorense* Chloroform – methanol extract.

Wave number (cm^{-1})	Suspected chromophores
3412.19	O-H stretch for alcohols, phenols and carboxylic acid.
2962.76	C-H stretch for alkanes and aromatics.
2842.20	C-H stretch for alkanes
2510.44	C=N stretch for nitriles
2125.63	C=C stretch for alkenes
1648.23	C=O stretch for ketones, acid amides and esters.
1424.48	C=C stretch for alkenes and aromatics
1105.25	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 8: Result of Fourier Transformed Infrared and Ultraviolet Spectra for *Erythrophleum Ivorense* Chloroform extract.

Wave number (cm^{-1})	Suspected chromophores
3435.34	O – H stretch for alcohols and esters
2845.10	C – H stretch for alkanes
2505.62	C = N stretch for nitriles
1643.41	C = O stretch for ketones, acid amides & esters
1460.16	C = C stretch for alkenes and aromatics
1107.18	C – O stretch for esters
489.94	C – H deformation bond for alkyl groups
UV λ_{max} 205 and 277	Indicating highly conjugated aromatic amide.

DISCUSSION

Table 1, indicated that *Erythrophleum Ivorense* 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. One can deduce from the result that *Erythrophleum Ivorense* wood could only dissolve in hot concentrated H_2SO_4 acids.

The thermal characteristics analysis carried out on the wood of *Erythrophleum Ivorense* showed that it had zero afterglow time (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 value indicated that it can moderately sustain combustion. Water imbibitions at 30 mins, 5 hrs and 24 hrs intervals showed the capacity of *Erythrophleum Ivorense* timber to absorb water over a period of time[16]. The oven dry density and ash content values are in line with the ascertain of [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 result also showed a high moisture content value of 31.0% which is in-line with [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 [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. [20],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. *Erythrophleum Ivorense* with high charring temperature of 70 - 81^{o}C 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. One can deduce from the results that *Erythrophleum Ivorense* is a hardwood that will be very good for construction and other purposes.

The results of the Atomic Absorption Spectrophometric analysis of the sample (Table 3) showed that copper, calcium, magnesium and potassium were present and are involved in body enzymatic activities.[21] Sodium and potassium help in P^{H} balance of body fluids, zinc which is essential for the activity of DNA polymerases, nucleic acid metabolism and cell division[16], arsenic and lead were also present while mercury and cadmium were absent.

The result of the phytochemical analysis (Table 4) showed the presence of all the analysed secondary metabolites which includes saponin, resins, alkaloids, tannin, protein, flavonoids, terpernoids, carbohydrate, steroid and glycosides. The medicinal values of medicinal plants lie on these phytocompounds which produce definite physicological actions in human body. 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. The presence of alkaloids showed that it can be used as antimycotics and also in the treatment of stomach pains,[15]. Protein indicated high nutritional value of the extract, therefore

can help in physical, mental growth and development.[13] Flavonoids exhibit an anti-inflammatory, anti-allergic effects, analgesic and anti-oxidant properties[22]Tanins are anti-inflammatory, control gastritics and irritating bowel disorders, they also contribute to antimicrobial power which heals wounds and stop bleeding[23] 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 and mental growth and development [17].

Results of Quantitative Chemical Constituents of *Erythrophleum Ivorense* (Table 5) indicated that the sample contained 25% of lignin, 42% of cellulose, 24% of hemicelluloses, etc 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.[24], [25] & [26] The destructive distillation of *Erythrophleum Ivorense* gave rise to four products in the following compositions; wood charcoal (2.0g), pyroligneous acid (2.5cm^3), wood tar (0.25cm^3) and wood gas (926 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. At 100^{o}C, the chemical bonds begin to break and are manifested as carbohydrate. Hemicellulose and lignin components are pyrolyzed in the temperature ranges of 200^{o}C - 300^{o}C and 225^{o}C - 450^{o}C respectively. Much of the acetic acid liberated from wood pyrolysis is attributed to deactylation of hemicelluloses. As a result of the vigorous production of flammable volaties from 300^{o}C - 450^{o}C, significant depolymerization of cellulose begins from 300^{o}C - 350^{o}C. Also around 300^{o}C aliphatic side chains starts splitting off from aromatic rings in the lignin. The carbon-carbon linkage between lignin structural units is cleaved from 370^{o}C - well in animal feed formulation. Crude fiber indicates the level of indigestible

component of food. Low crude fiber content shows that the sample has high nutritional value.[27] There depicts low oxalate content (0.92g/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.[28] The high lipid content of 6.80% in *Erythrophleum Ivorense* wood proves energy storage capacity in the structural component of the sample's cell membrane.[29]

The thin layer chromatography of the extracts (Table 6) showed one component each with R_f values of 0.68 and 0.69 when chloroform and chloroform-methanol extracts were respectively spotted. The TLC result confirmed the presence of some components and its high purity.

From the FTIR and UV spectra of the isolated compounds, the bands observed are summarized in Tables 7 and 8. The O-H stretching band at 3435.34cm^{-1} and 3412.19 cm^{-1} of alcohols, phenols and esters. The C-H stretching at 2956.97cm^{-1}, 2962.76cm^{-1} and 2845.10cm^{-1} corresponds to that of an aliphatic C-H. The C=N absorption peak for nitriles appeared at 2505.62cm^{-1} and 2510.44cm^{-1}. The C=O stretching bands at 1643.41cm^{-1} and 1648.23cm^{-1} are that of ketones, acid amides, esters and carboxylic acids. The C-O absorption peak for alcohols, esters and carboxylic acids appeared at 1107.18cm^{-1} and 1105.25cm^{-1} while the C-H deformation bonds for alkyl groups occurred at 1018.45cm^{-1} and 1020.38cm^{-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 *Erythrophleum Ivorense* results of thermal and variable characteristics, phytochemical and AAS analysis of the wood, had shown that it contained some components that could made it useful in animal feed formulation and as well a good material for various construction works. The UV and FTIR spectra showed that it contains some bioactive compounds. The presence of many secondary metabolites showed that *Erythrophleum Ivorense* could 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 that *Erythrophleum Ivorense* is a hardwood that could be very effective in various construction works and as 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.

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