THE STUDY OF CHARACTERISTICS, CHEMICAL CONSTITUENTS AND FUNCTIONAL GROUP ANALYSIS OF *Afzelia bipindensis*: A TROPICAL TIMBER

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Abstract: The dearth of information on the wood stem of *Afzelia bipindensis* led to the evaluation of its chemical, physical, phytochemical and functional groups analysis. Some obtained results from physical and thermal analysis were as follows; oven dry density 51.4 x 10^{-2} g.cm^{-3}, water imbibitions (at different intervals: 30 min 22.2%, 5 h 37% & 24 h 59.1%), thermal conductivity 26.31 x 10^{2} Umoh/cm, electrical conductivity 5.0 x 10^{-3} Sm^{-1}, afterglow time 49.33Sec, flame duration 181.33Sec, flame propagation rate 4.6 x 10^{-2} cm.S^{-1}, ignition time 8.33Sec, moisture content 20.28% and ash content 1.74% showed that it is a good timber that could be suitable for various construction purposes. Phytochemical screening showed the presence of saponins, tannins, steroids, flavonoids, carbohydrates, proteins, resins, terpenoids, glycosides and alkaloids. The AAS of the sample showed the presence of some metals such as Na, K, Pb, Ca, Zn, Mg, As and Cu in the decreasing order of their concentrations. The Thin Layer Chromatographic analysis showed two spots for chloroform extract. It was further characterized using Fourier Transform Infrared and Ultraviolet Spectroscopic methods which suggested a 1,2,3- trisubstituted phenylamide with NH, CO and CN groups attached as the functional groups present. The chemical components analysis showed the presence of cellulose, hemicelluloses, lignin and other constituents in their right proportion. The results confirmed the effectiveness of the wood for various construction purposes and its medicinal ability due to the presence of all the analyzed secondary metabolites.

Keywords: *Afzelia bipindensis,* phytochemical, functional group, tropical timber

Introduction

Afzelia bipindensis is a tree species that belongs to the Fabaceae Family. It is softwood with *Afzelia* as its common name. In Nigeria, its Igbo name is aja, olutoko in Yoruba and rogon daji in Hausa (Keay *et al.,* 1964; Keay, 1989). It occurs in Burkinafaso, Cameroon, Central Africa Republic, Chad, Republic of Congo, Democratic Republic of Congo, Ivory Coast, Guinea Bissau, Mali, Niger, Nigeria, Senegal, Sierra Leone, Sudan, Togo, Angola and Uganda (Jackson, 2012).

In Nigeria, it is located mostly in Benin (Udeozo *et al.,* 2011). Like other *Afzelia* spp., the wood of *A. bipindensis* is characterized by an excellent stability with little susceptibility to variations in humidity, small shrinkage rates during drying and a good natural durability. The wood is durable and treatment with preservatives is unnecessary, even for usage in permanent humid conditions or in localities where wood-attacking insects are abundant. This makes it an excellent wood for use in pleasure-crafts, especially for keels, stems and panels, for bridges, as well as interior fittings. For such uses it is sometimes as much in demand as teak.

The wood is also valued for joinery and panelling, both interior and exterior, parquet floors, doors, frames, stairs, vehicle bodies, furniture, sporting goods, mine props, musical instruments, railway sleepers, agricultural implements, utensils, tool handles, turnery, fibre board and particle board. It is suitable for decorative sliced veneer. Because of its good resistance to many chemical products and great dimensional stability, it is often preferred to materials like metals and synthetics for vats and precision equipment in industrial applications. The neutral pH of the wood makes it suitable for applications in contact with vulnerable objects such as antiques and old books in libraries.

However, it should not be used in contact with textiles under more humid conditions because of the presence of colorants. The wood is also used as firewood and for charcoal production. In Cameroon the bark exudate is taken to treat stomach-ache. The seed aril is applied to chapped lips (Gérard & Louppe, 2011).

Afzelia bipindensis mature trees grow between 10 to 20 metres in height (Jackson, 2012). It occurs in evergreen and semi-deciduous forest up to 900 m altitude, usually on well-drained localities, in primary as well as secondary forest. The wood has a good reputation for its resistance to acids and alkalines. The heartwood is durable, with an excellent resistance to fungal, termite and borer attacks, and moderate resistance to marine borers. The sapwood is susceptible to *Lyctus* attack. The natural durability of the wood is partly due to the presence of certain protective compounds; after extraction with a series of solvents the wood lost much of its resistance to fungal attack. The heartwood is resistant to impregnation with preservatives. Saw dust may cause allergic reactions, irritation of mucous membranes and asthma in wood workers. (Gérard & Louppe, 2011)

They are prized for their quality wood, their bark which has many medicinal uses and their nitrogen-rich leaves which enrich the soil. It was also used in the middle ages for ship building (Jackson, 2012). There is need for more information on the wood of *Afzelia bipindensis;* 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

Healthy looking wood from the stem of *A. bipindensis* used for this study was collected from timber shed at Benin, Edo State, Nigeria. Timber dealer, forest officer (Mr. Vin Okakpu of Nnewi Forestry) as well as literature (Keay *et al.,* 1964) helped in the timber identification.

Sample preparation

The sample was first dried in an oven at 105°C for 24 h, 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. Then, ground to fine powder and stored in a clean dry covered plastic container ready for the analysis.

Method

The physical and thermal characteristics

The sample was screened for the values of some physical and thermal characteristics which includes; afterglow time, flame duration, flame propagation, ignition time, oven dry density, moisture content, water imbibitions, ash percentage, thermal conductivity and electrical conductivity using American Society for Testing and Material (ASTM, 1998, 1999) methods.

Micro element composition

In determining of the trace metal elements, Atomic Absorption Spectrophotometer model PG 990 manufactured by PG instrument Ltd U.S.A. was used.

Solubility analysis

The sample solubility was determined by placing 1 g of the sample powder into nine different 250 cm^3 Kjeldahl flasks. 20 cm^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.

The phytochemical compounds

A qualitatively and quantitatively screening of resins, steroids, terpenoids, tanins, alkaloids, saponin, flavonoids, glycosides, phlobatannins, carbohydrate and protein were done by the methods outlined by Harbone (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.

The chemical compositions

A quantitative determination of the sample for lignins, hemicellulose, cellulose, crude fibre, crude protein, carbohydrate, phenol and destructive distillation of the wood products was done using the methods outlined by Goering & Vansoest (1975), Oakley (1984) and Marzieh & Marjan (2010).

The functional group analysis

The samples chloroform extract was monitored using TLC, Fourier Transform Infrared and Ultraviolet Spectroscopic methods.

Results and Discussion

The results of the study are presented in Tables 1- 8. The physical and thermal characteristics analysis carried out on the wood of *Afzelia bipindensis* showed that it had low 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 min, 5 h and 24 h intervals showed the capacity of *Afzelia bipindensis* timber 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 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 moisture content value of 21.28% which is in-line with Arntzen (1994) 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 (1964), 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. David *et al.* (1999) 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. *Afzelia bipindensis* with high charring temperature of 88-110^oC 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 *Afzelia bipindensis* is softwood that will be very good for construction and many other purposes.

Table 1: *Afzelia bipindensis* physical and thermal characteristics

Characteristics	Units	Results
Afterglow time	Sec	49.33
Flame duration	Sec	181.33
Flame propagation rate	$cm.S^{-1}$	4.6×10^{-2}
Ignition time	Sec	8.33
Over dry density	$g.cm^{-3}$	51.4×10^{-2}
Moisture content	%	20.28
30 min Water imbibitions	%	22.2
5 h Water imbibitions	%	37
24 h Water imbibitions	%	59.1
Ash Content	%	1.74
Thermal conductivity	Umoh/cm	26.31×10^2
Electrical Conductivity	Sm^{-1}	5.0×10^{-3}
Specific Gravity		0.42
Porosity Index	%	1.32
PH		6.65
Charring Temperature	^oC	88 – 110
Colour		Cornsilk

Table 2: Trace element composition of *Afzelia bipindensis*

Trace element	Result (%)
Zinc	0.1
Lead	0.16
Cadmium	Nil
Copper	0.008
Sodium	1.21
Calcium	0,11
Magnesium	0.07
Potassium	1.00
Arsenic	0.01
Mercury	Nil

Table 3: The Solubility Property of *Afzelia bipindensis*

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

The *Afzelia bipindensis* stem contained some essential minerals which are of great importance in the formulation of animal feeds as confirmed by the Atomic Absorption Spectrophotometric analysis results. It indicated that copper, magnesium and potassium were present and are involved in body enzymatic activities, Sodium which helps in P^H balance of body fluids, zinc which is essential for the activity of DNA polymerases, calcium which is an important constituent of skeleton and bones, lead and arsenic were also present while mercury and cadmium were absent.

The solubility examination showed that *Afzelia bipindensis* wood powder similar to some other wood powder (Udeozo *et al*., 2016) 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 *Afzelia bipindensis* wood could only dissolve in hot concentrated H_2SO_4 acids.

Table 4: Qualitative Phytochemical test of *A. bipindensis*

Phytochemicals	Inference
Saponin	++
Flavonoids	+
Resins	+
Steroids	+++
Terpenoids	++
Tannin	++
Alkaloids	+
Carbohydrate	+
Protein	++
Glycoside	+++

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

Table 5: Chemical compositions of *Afzelia bipindensis*

Chemical Constituents	Units	Results
Lignins	%	20.5
Hemicellulose	%	27.0
Cellulose	%	46.0
Crude Fibre	%	2.0
Crude Protein	%	3.89
Carbohydrate	Mg/g	1.62
Phenol	Mg/g	0.26
Tannin	Mg/100g	930
Alkaloids	%	7.6
Flavonoids	%	2.0
Saponins	%	6.8
Oxalate	g/100g	2.0
Total Acidity	g/100cm^3	0.45
Cyanogenic Glycoside	Mg/100g	761
Lipid	%	3.6
Wood Charcoal	(g)	2.5
Pyroligneous acid	cm^3	3.0
Wood tar	cm^3	0.25
Wood gas	cm^3	998

The result of the phytochemical analysis showed the presence of all the analysed secondary metabolites which ranges from glycosides, steroids, terpenoids, saponin, tannin, protein, flavonoids, alkaloids, resins and carbohydrate in their increasing order of magnitude. 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. Terpenoids are associated with anti-cancer and also play a role in traditional and alternative medicine such as aromatherapy, antibacterial and other pharmaceutical functions. Tanins are anti-inflammatory, control gastritics and irritating bowel disorders, they also contribute to antimicrobial power which heals wounds and stop bleeding (Gills, 1992). 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). The carbohydrate presence in the sample extract showed that it is a good source of energy. 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 and mental growth and development (Udeozo *et al*., 2014)

Quantitative Chemical Constituents results of *Afzelia bipindensis* indicated that the sample contained 20.5% of lignin, 46% of cellulose, 27% of hemicelluloses, etc which help to confirm that the sample is softwood. Lignin is largely responsible for the strength, rigidity of plant and shields carbohydrate polymers from microbial and enzymatic attack. It contributes 20-30% of softwood. Cellulose, a major chemical component of wood fibre wall, contributes 40-50% of softwoods 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 25-30% of softwood (Arntzen, 1994; Desch & Dinwoodie, 1996). The destructive distillation of *Afzelia bipindensis* gave rise to four products in the following compositions; wood charcoal (2.5 g), pyroligneous acid (3.0 cm^3), wood tar (0.25 cm^3) and wood gas (998 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 - 300^{o}C and 225 - 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 - 450^{o}C, significant depolymerization of cellulose begins from 300 - 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 (AOAC., 1990). There depicts low oxalate content (2.0 g/100g) 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 (Fatoki and Ekwenchi, 1998). The lipid content of 3.60% in *A. bipindensis* wood proves energy storage capacity in the structural component of the sample's cell membrane (Fahy *et al*., 2009).

The thin layer chromatography of the extract showed two components with R_f values of 0.8 and 0.5 when chloroform extract was spotted. The TLC results confirmed the presence of some components and its high purity.

Table 6: Results of thin layer chromatographic characteristics of chloroform stem extract of *A. bipindensis*

Sample	Number of spot	Rf value
Chloroform extract	2	0.8 & 0.5

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

Wave number (cm^{-1})	Suspected chromophores
3430.51	N – H stretch for amides
2105.37	C = N stretch for nitriles
1646.30	C = O stretch for ketones, acid amides & esters
1448.59	C = C stretch for alkene and aromatics
1021.34	C – O stretch for esters
464.85	C – H deformation bond for alkyl groups
UV λ_{max} 213, 282 and 751	Indicating highly conjugated trisubstituted aromatic compound.

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

Wave number (cm^{-1})	Suspected chromophores
3425.69	N – H stretch for amines
2110.19	C = N stretch for nitrile
1645.33	C = O stretch for ketones, acid amides & esters
1464.02	C = C stretch for alkenes and aromatics
1022.31	C – O stretch for esters
463.90	C – H deformation bond for alkyl groups
UV λ_{max} 366, 503 and 584	Indicating highly conjugated aromatic amide.

From the results of the FTIR and UV (Table 7), it showed strong absorption at 3430.51 and 2105.37 cm^{-1} which indicated the presence of amides and nitriles. The absorption at 1646.30 and 1448.59 cm^{-1} showed the presence of ketones, acid amides, esters and alkenes. The presence of N-H, C=N and C=O (Table 8) for hydrogen bond in amines, nitriles and ketones were shown by absorption at 3425.69, 2110.19 and 1645.33 cm^{-1}, respectively. The absorption in the ultraviolet visible spectra and FTIR spectra suggested that the active compound might be 1,2,3-trisubstituted aromatic compound with N-H, C=O and C=N groups attached.

Conclusion

From the findings of this study, it was observed that thermal and variable characteristics, phytochemical and AAS analysis of the wood, *Afzelia bipindensis* 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 all the analyzed secondary metabolites revealed that *A. bipindensis* 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 *A. bipindensis* is a softwood that could be very efficacious 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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