Global Journal of Biotechnology & Biochemistry 10 (3): 121-125, 2015
ISSN 2078-466X

DOI: 10.5829/idosi.gjbb.2015.10.03.101116

The Efficacy of *Pycnanthus angolensis* Timber: An Assay of its Properties, Chemical Constituents and Functional Group Analysis

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Abstract: The evaluation of the wood of *Pycnanthus angolensis* was carried out in terms of chemical, physical and variable techniques. Phytochemical screening showed the presence of saponins, tannins, steroids, flavonoids, carbohydrates, proteins, resins, terpenoids, glycosides and alkaloids. The Atomic absorption spectroscopy [AAS] of the sample showed the presence of some metals such as Na, K, Pb, As, Ca, Zn, Mg and Cu in the decreasing order of their concentrations. The thin layer chromatographic analysis of the chloroform-methanol extract which gave two spots with Rf values of 0.6 and 0.5 was further characterized using Fourier Transform Infrared and Ultraviolet Spectroscopic methods. The Fourier Transform Infrared and Ultraviolet spectra suggested a 1,2,3- trisubstituted phenylamide with OH,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 efficiency of the wood for various construction purposes and its medicinal ability due to the presence of the secondary metabolites.

Key words: Chloroform-Methanol · Phytochemical Screening · *Pycnanthus angolensis*

INTRODUCTION

Pycnanthus angolensis is a species of tree in the nutmeg family, myristicaleae. It is a hardwood, native to tropical Africa. Its English common names include Africa nutmeg, false nutmeg, box board and cardboard. In Africa, it is widely known as koma. In Nigeria, its Igbo name is akwa-mili, akomu in Yoruba and akujaadi in Hasusa. It is mostly located at Calabar and Awka [1, 2].

This evergreen tree grows up to 40 meter tall, the trunk is straight and cylindrical with tissues, flaking bark and honey colored sap. It grows in moist rain forest up to about 1200 meter in elevation among other evergreens and semi deciduous trees. It occurs in secondary forest, sometimes taking hold in new canopy gaps or clearing. It thrives in sunny location, grows in riparian forest such as gallery forest and in some regions, if found in swamp, it occurs in area receiving between about 1300 and 1800 millimeter of rain per year.

In Uganda, it is grown in banana, coffee and cocoa plantation to share the gop. The sap has been used to control bleeding, whereas, the bark as a poison antidote and treatment of leprosy, anemia, infertility, gonorrhea and malaria [3]. There is paucity of information on the wood of *P. angolensis,* as a result, some thermal and variable properties, chemical constituents, phytochemical and functional group assay of the wood were investigated.

Experimental

Sample Collection and Identification: *Pycnanthus angolensis* timber was collected from timber shed at Awka in Awka North Local Government Area of Anambra State. Timber dealer, forest officer (Mr. Vin Okakpu of Nnewi Forestry) as well as literature helped in the timber identification.

Sample Preparation: The 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 0.5cm and cubes of dimensions 2.5 x 2.5 x 2.5cm. The samples were dried in an oven at 105°C for 24 h before the experiments.

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Methods

The Thermal Characteristics: 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 American Society for Testing and materials [4], American Society for Testing and materials [5] and American Society for Testing and materials [6]. 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 [7].

The hydrogen ion concentration (PH) was determine by the method outlined by Amadi *et al.* [8] 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 and Vansoest[9], Oakley [10] and Marzieh and Marjan [11].

The chloroform-methanol 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 timber extract of *P. angolensis* are given in Tables 1- 8.

The solubility analysis result (Table 1) showed that *P. angolensis* powder completely dissolved only in the presence of concentrated tetraoxosulphate (vi) acid at high temperature. Therefore, the sample is resistant to polar, organic and corrosive substances except highly corrosive hot acid. This is in line with [12] 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.

Thermal characteristics analysis carried out on the wood of *P. angolensis* (Table 2) showed that it had high flame duration value of 170 sec which indicated that it could sustain itself till the whole length of wood got burnt. Afterglow time value of more than four minutes showed that it would glow long enough for rekindle to take place as a result could be hazardous in fire situations. Water imbibitions at 30 min, 5 h and 24 h intervals with respective values of 32.7%, 53.7% and 91.3% showed the capacity of *P. angolensis* wood to absorb water over a period of time [13]. The oven dry density and ash content values are in line with the ascertain of Desch and Dinwoodie [14] which stated that denser and small ash content timbers are suitable in their use as a source of carbondioxide for internal combustion engine. One can deduce from the result that *P. angolensis* is a hardwood that will be very good for construction and other purposes.

The result of the phytochemical analysis (Table 3) showed the presence of all the tested secondary metabolites which includes; flavonoids, alkaloids, saponin, protein, resins, 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 [15]. The presence of alkaloids showed that it can be used as antimycotics and also in the treatment of stomach pains [16]. 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 [17]. 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. 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 [18].

The results of the Atomic Absorption Spectrophometric analysis of the sample (Table 4) 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

Table 1: Results of the Solubility Property of *Pycnanthus angolensis*

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 the thermal and physical characteristics of *Pycnanthus angolensis*

Characteristics	Units	Results
Afterglow time	Sec	282
Flame duration	Sec	170
Flame propagation rate	$cm.5^{-1}$	7.1×10^{-2}
Ignition time	Sec	17.28
Over dry density	$g.cm^{-3}$	44.7×10^{-2}
Moisture content	%	17.28
30 mins Water imbibitions	%	32.7
5 hrs Water imbibitions	%	53.7
24 hrs Water imbibitions	%	91.3
Ash Content	%	1.82
Thermal conductivity	Umoh/cm	27.5×10^2
Electrical Conductivity	Sm^{-1}	6.1×10^{-3}
Specific Gravity		0.36
Porosity Index	%	1.56
PH		6.09
Colour		Chocolate

Table 3: Phytochemical composition of *Pycnanthus angolensis*

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

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

Table 4: Micro elemental composition%

Zinc	0.05
Lead	0.93
Cadmium	Nil
Copper	0.012
Sodium	2.29
Calcium	0.06
Magnesium	0.01
Potassium	1.10
Arsenic	0.22
Mercury	Nil

Table 5: Results of Quantitative Chemical Constituents of *Pycnanthus angolensis*

Chemical Constituents	Units	Results
Lignins	%	22.0
Hemicellulose	%	24.0
Cellulose	%	45.0
Crude Fibre	%	0.2
Crude Protein	%	2.33
Carbohydrate	Mg/g	0.92
Phenol	Mg/g	1.96
Tannin	Mg/100g	810
Alkaloids	%	7.6
Flavonoids	%	3.8
Saponins	%	2.8
Oxalate	g/100g	1.46
Total Acidity	$g/100cm^3$	0.36
Cyanogenic Glycoside	Mg/100g	480
Lipid	%	0.8
Wood Charcoal	(g)	3.0
Pyroligneous acid	cm^3	2.75
Wood tar	cm^3	0.1
Wood gas	cm^3	762

important role in maintenance of osmotic, electrolytic balance and proper rhythm of clothing. Magnesium is for signaling the nervous system and also participates in osmotic and electrolyte balance but can cause genetic disorder [19]. 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 [20, 21]. Lead and arsenic were also present while mercury and cadmium were absent.

Results of Quantitative Chemical Constituents of *P. angolensis* (Table 5) indicated that the sample contained 22% of lignin, 45% 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 45-50% 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 [13, 22-24]. The destructive distillation of *Pycnanthus angolensis* gave rise to four products in the following compositions; wood charcoal (3.0g), pyroligneous acid ($2.75cm^3$), wood tar ($0.1cm^3$) and wood gas ($762\ cm^3$). 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°C, the chemical bonds begin to break and are

Table 6: Results of Thin layer chromatographic characteristics of chloroform-methanol extracts

Sample	Number of spot	Rf value
Chloroform-methanol extract.	2	0.6 & 0.5

Tables 7: Results of Fourier Transformed Infrared and Ultraviolet spectra of Chloroform –methanol 1st spot extract.

Wave number (cm^{-1})	Suspected chromophores
3431.48	O-H stretch for alcohols, phenols and carboxylic acid
2959.87	C-H stretch for alkanes and aromatics
2847.99	C-H stretch for alkanes
2517.19	C=N stretch for nitriles
2149.74	C=N stretch for nitriles
1652.09	C = O stretch for ketones, carboxylic acid, amides & esters
1450.52	C=C stretch for alkene and aromatic rings
1105.86	C–O stretch for alcohols, esters and carboxylic acids
1022.31	C–H deformation bonds for alkyl groups
UV_{max} 366.50 and 671.50	Indicating highly conjugated trisubstituted aromatic compounds.

Table 8: Result of Fourier Transformed Infrared and Ultraviolet Spectra of Chloroform– methanol 2nd sport extract

Wave number (cm^{-1})	Suspected chromophores
2951.19	C–H stretch for alkanes and aromatics
2840.28	C–H stretch for alkanes
2521.05	C=N stretch for nitriles
2166.13	C=N stretch for nitrile
1653.05	C=O stretch for ketones, acid amides and esters
1439.91	C=C stretch for alkene and aromatics
1113.93	C–O stretch for alcohols, carboxylic acids and esters
1023.27	C–H deformation bonds for alkyl groups
UV_{max} 306.50 and 753.00	Indicating highly conjugated 1,2,3 trisubstituted aromatic compounds.

manifested as carbohydrate. Hemicellulose and lignin components are pyrolyzed in the temperature ranges of 200°C - 300°C and 225°C - 450°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°C - 450°C, significant depolymerization of cellulose begins from 300°C - 350°C. Also around 300°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°C - 400°C [24].

The thin layer chromatography of the chloroform-methanol extract (Table 6) showed two components with R_f values of 0.6 and 0.5. The TLC results 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 3431.48cm^{-1} is of alcohols, carboxylic acid and phenols. The O-H can be said to be associated. The C-H stretching at 2959.87cm^{-1}, 2951.19cm^{-1}, 2847.99cm^{-1} and 2840cm^{-1} corresponds to that of an aliphatic C-H. The C=N absorption peak for nitriles appeared at 2517.19cm^{-1} and 2166.13cm^{-1}. The C=O stretching bands at 1652.09cm^{-1} and 1653.05cm^{-1} are that of ketones, acid amides, esters and carboxylic acids. The C-O absorption peak for alcohols, esters and carboxylic acids appeared at 1105.56cm^{-1} and 1113.93cm^{-1} while the C-H deformation bonds for alkyl groups occurred at 1022.31cm^{-1} and 1023.27cm^{-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 and variable characteristics, phytochemical and AAS analysis of the timber, *P. angolensis* 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 *P. angolensis* 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 *P. angolensis* is a hardwood and could be very effective in various construction works.

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