J. Chem. Soc. Nigeria, Vol. 46, No.2, pp 0341 – 0350 [2021]

Determination of Physico-chemical properties of selected tropical timbers in Anambra State, South Eastern Nigeria

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Received 02 September 2020; accepted 29 September 2020, published online 3 April 2021

ABSTRACT

The analyses on chemical properties of some tropical timbers have been studied. The physical properties of these timbers varied in the pH(4.26 – 6.85) , moisture content(13%-37%), specific gravity(0.16-0.45), charring temperature (61 – 116^{o} C)and porosity index(1.17-2.08%).Also the solubility behaviors of these timbers were mostly insoluble in hot and cold water, NaOH and ethanol and slightly soluble in concentrated HCl and H_2SO_4 respectively. The Qualitative results show heavy presence of flavonoids, saponins, tannis, glycosides, steroids and terpenoids in some of the timbers.Quantitative determinations were carried out and results show that the woods contain chemical constituents which are useful to both humans and industries.

Keywords: Tropical Timber, Solubility, Qualitative analysis, Quantitative analysis

INTRODUCTION

Wood is an important eco - friendly material that occurs in nature [1]. It is renewable and a good source of energy. The quality of woods depends on its resistance to heat, porosity index, among others [1]. A lot of woods are brought down by foresters and are used as fuel, timber and fibers [1]. Woods have been reported to be a material that is anisotropic and orthotropic in nature [2]. Much research has been carried out on the phytochemical analyses of plants, plant leaves and seeds [3,4]. Also, the nutritional and medicinal values of *Moringa oleifera* leaves from sub-Saharan Africa: Ghana, Rwanda, Senegal and Zambia has been reported [5]. Antibacterial, phytochemical and antioxidant activities of the leaf extracts of *Gliricidia sepium* and *Spathodea campanulata*, with differences in chemical components of the plants' extracts have all been studied. Anambra state is one of the eastern states created in 1991 with approximate landmass of 8222km.

Therefore, the aim of this study is to identify the physical properties and chemical constituents of these tropical timbers collected from anambra state

MATERIALS AND METHODS

Preparation of wood samples

Wood samples (Timber) were grounded into fine powder using grinding machine. 5g of the powder samples were kept in air- tight polyurethane bags, until required.

Determination of the pH and moisture content

The pH, specific gravity was performed using reported methods [6, 7] and Moisture content was determined according to literature report using equations (1)

$$\%\text{moisture} = \frac{\text{Wt of wet wood sample - Wt of oven dry wood sample}}{\text{Wt of oven dry wood sample}} \times \frac{100}{1} \quad (1)$$

Determination of the charring temperature, colour and porosity index

The charring temperature, porosity index, solubilityandcolour were determined using a reported work.Theporosity Index was calculated using equation (2).

$$\text{Porosity index} = \frac{\text{Weight of dry starch wood sample soaked in oil}}{\text{Weight of dry starch wood sample}} \quad (2)$$

Proximate composition

The proximate compositionwere studied by determining Lipids [8] Crude protein [6], Crudefibre [9], Total lignin content [10], Hemicellulose [10], Cellulose and ash content [6] using standard and reported methods.

Chemical properties of the wood samples

The chemical properties of the wood samples were carried out qualitatively by determining the tannins, phlobatannins, Saponin, Steroid, Terpenoids, [13]. Flavonoid [14, 15],Alkaloids, Cyanogenic Glycoside [16] using reported work

Determination of the charring temperature, colour and porosity index

The charring temperature, porosity index, solubility and colour were determined using a reported work [17]. The porosity Index was calculated using equation (2).

$$\text{Porosity index} = \frac{\text{Weight of dry starch wood sample soaked in oil}}{\text{Weight of dry starch wood sample}} \quad (2)$$

Quantitative determination of the chemical constituents of the wood sample

The chemical properties of the wood samples were carried out quantitatively using reported works by determining tannins, Total Acidity, Cyanogenic Glycoside [6] phlobatannins, Saponin[18] Steroid, Terpenoids,[13]. Flavonoid [19] Alkaloids [15], Oxalate [18] as presented in equations (3-6)

$$\text{Tannic acid (mg/100g)} = \frac{C \times \text{extract volume} \times 100}{\text{Aliquot volume} \times \text{weight of sample}} \quad (3)$$

C = concentration of tannic acid, extrapolated from the graph.

$$\% \text{ Alkaloid} = \frac{\text{Weight of alkaloid}}{\text{Weight of sample}} \times \frac{100}{1} \quad (4)$$

$$\% \text{ flavonoid} = \frac{\text{Weight of flavonoid}}{\text{weight of sample}} \times \frac{100}{1} \quad (5)$$

$$\% \text{ Saponin} = \frac{\text{Weight of saponin}}{\text{Weight of sample}} \times \frac{100}{1} \quad (6)$$

Thermal properties of the wood samples

The thermal properties of the woods were determined using reported methods [17, 20].

RESULTS AND DISCUSSION

Sample collection and identification

Twenty wood samples indigenous to Anambra state were obtained from Nnewi timber market in Anambra state. The timbers were identified and confirmed with the aid of literature [21], botanical and local names of the timbers were confirmed by Mr Okakpu Vincent a forest officer at Nnewi forestry, Nigeria and the timber dealers respectively. (Table 1) shows the classification of the various timbers used.

Table 1: Classification of timbers according to their botanical and local name

S/N	WoodSample (Botanical Name)	Botanical families	Igbo Names	Yoruba Names	Hausa Names	Areas of Location
1.	PycnanthusAngolensis	Myisticaceae	Akwa-mili	Akomu	Akujaadi	Awka
2.	CaloncobaGlauca	Flacourtiaceae	Udalla-enwe	Kakandika	Alibida	Onitsha
3.	BarteriaFistulosa	Passifloraceae	Oje	Ayin	Kadanya	Awka
4.	AnogeissusLeiocarpus	Combretaceae	Atara	Egba	Marike	Awka
5.	Garcinia Kola	Clusiaceae	Adi	Atori	Namijin-goro	Onitsha
6.	Cola Laurifolia	Stericuliaceae	Ufa	Awori	Karanga	Onitsha
7.	BrideliaFerruginea	Euphorbiaceae	Ola	Abo-emido	Kirni and kizni	Awka
8.	UapacaGuineensis	Euphorbiaceae	Obia	-	Wawankurmi	Onitsha
9.	AntidesmaVenosum	Euphorbiaceae	Okoloto	Aroro	Kirni	Onitsha
10.	Parinari Robusta	Chysobalanaceae	Ohaba-uji	Idofun	Kasha-kaaji	Onitsha
11.	CynometraVogelii	Fabaceae	Ubeze	Anumutaba	Alibida	Onitsha
12.	OncobaSpinosa	Flacourtiaceae	Akpoko	Kakandika	Kokochiko	Onitsha
13.	DichapetalumBarteri	Dichapetalaceae	Ngbuewu	Ira	Kirni	Onitsha
14.	DichrostacysCinerea	Fabaceae	Amiogwu	Kara	Dundu	Onitsha
15.	PentaclethraMacrophylla	Leguminosae	Ugba	Apara	Kiriya	Onitsha
16.	TetrapleuraTetraptera	Leuminosae-Mimosoideae	Oshosho	Aridan	Dawo	Onitsha
17.	StemonocoeusMicranthus	Leuminosae-Caesalpinioideae	Nre	-	Waawankumii	Awka
18.	HymenocardiaAcida	Euphorbiaceae	Ikalaga	Orupa	Jan yaro	Awka
19.	MacarangaHurifolia	Humiriaceae	Awarowa	Ohaha	-	Akwa
20.	Cordial Millenii	Meliaceae	Okwe	Okwe	-	Onitsha

Physical properties of the wood samples

The properties and usefulness of these woods are evident ranging from construction of houses, garden, fence, flooring, furniture, ships to making of musical instruments, utensils, creating art works and as source of fuel [22]. The results on the physical properties of the twenty timbers are presented in table 2 below.

Table 2: the physical properties of the wood sample

S/N	Wood Sample (Botanic names)	pH Values	Moisture Content (%)	Specific Gravity	Charring Temperature (^{0}C)	Porosity index (%)
1.	Pycnanthusangolensis	6.09	25.0	0.36	97 – 110	1.56
2.	Caloncobaglauca	6.09	36.0	0.30	71 -98	1.21
3.	Barteriafistulosa	6.85	30.0	0.31	90 -101	1.33
4.	Anogeisssusleiocarpus	6.26	13.0	0.25	82 -106	1.31
5.	Garcinia kola	6.72	28.0	0.37	75 – 88	1.32
6.	Cola laurifolia	6.6	25.0	0.34	64 – 90	1.17
7.	Brideliaferruginea	6.28	25.0	0.38	98 - 116	1.36
8.	Uapacaguineensis	5.3	25.0	0.44	78 – 86	1.55
9.	Antidesmavenosum	4.26	27.0	0.49	90 – 107	1.75
10.	Parinarirobusta	6.65	36.0	0.25	98 – 111	1.73
11.	Cynometravogelii	5.31	13.0	0.44	71 – 85	1.65
12.	Oncobaspinosa	6.37	37.0	0.21	78 – 89	1.18
13.	Dichopetalumbarteri	6.64	24.0	0.16	82 – 96	1.86
14.	Dichrostacyscinerea	6.09	28.0	0.13	75 – 97	1.48
15.	Pentaclethramacrophylla	6.64	16.0	0.40	80 – 109	1.37
16.	Tetrapleuratetraptera	6.55	37.0	0.26	61 – 92	1.31
17.	Stemonocoleusmicranthus	6.72	29.0	0.24	64 – 92	2.08
18.	Hymenocardiaacida	6.55	33.0	0.33	70 – 84	1.90
19.	Macarangahurifolia	6.28	18.0	0.45	66 – 74	1.46
20.	Cordial millenii	6.65	30.0	0.36	91 – 103	1.38

The pH value of the wood ranged from 4.26 to 6.85, with *Barteriafistulosa* having the highest pH value of 6.85. This is in contrast to a reported work in which the pH of different softwoods varied ranged from acidic to alkaline through neutral values [3]. The pH values of the wood sample are slightly acidic, thus they contain some acidic components like tannic acid which are used in leather and textile industries. The acidity in wood is caused by free acetic acid found in wood as reported by [23]. The moisture content of wood is usually a percentage of the weight of oven dry wood [24]. This moisture content of a wood is relative to its strength [25], and thus determines its durability, service life, indoor and outdoor uses of the wood [20]. *Oncobaspinosa* and *Tetrapleuratetraptera* has the highest moisture content of 37% respectively while *Cynometravogelii* has the lowest moisture content of 13%. The woods with high moisture content will be durable with long service life when used for construction and art work purposes, while woods with low moisture content will be useful as source of fuel. The specific gravity result reveals that *Antidesmavenosum* has the highest specific gravity of 0.49, followed by*Macarangahurifolia* with specific gravity of 0.45 and *Dichrostacyscinerea* with the lowest specific gravity of 0.13. Specific gravity is an excellent

index of the amount of wood substance contained in a piece of wood as it reflects the presence of gums, resins and extractives, which contributes to the mechanical properties of the woods [26]. The charring temperature is the principal factor that determines the structural load-carrying capacity of wood in fire. The charring temperature of the analysed wood varied from 71 – 85^{o} C to 98 – 116 ^{o} C. *Cynometravogelii* has the lowest charring temperature while *Brideliaferruginea* has the highest charring temperature. Thus wood with high rate of charring temperature will have a higher ability of load-carrying capacity than woods with low charring temperature rate. The porosity index analysis reveals the void spaces in the wood which are occupied by mineral salts, air and water [3].*Stemonocoleusmicranthus* has the highest porosity index value of 2.08% while *Cola laurifolia* has the lowest porosity index value of 1.17%. The porosity of a wood also has been reported to affect the mechanical properties of the wood, thus wood with low porosity could be used for any purposes because they have high compressed grain particles than woods with high porosity index [3].

Solubility behaviour of different woods

The results of the wood solubility are shown in (Table 3) below, results reveal that all woods have similar solubility behavior. The woods were insoluble in hot water, cold water, sodium hydroxide and ethanol. The woods were slightly soluble in both in concentrated HCl and H_2SO_4, but on heating it was still slightly soluble in concentrated HCl but soluble in concentrated H_2SO_4.The solubility behavior result shows that the woods were resistant to organic, polar and corrosive solvent except highly corrosive heated acids [1].

Table 3: The solubility behaviour of the wood samples

S/N	Wood Sample (Botanic names)	Hot and cold water	1% NaOH and Ethanol	Concentrated HCl and Concentrated H_2SO_4	Concentrated HCl + heat	Concentrated H_2SO_4 + heat
1.	Pycnanthusangolensis	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
2.	Caloncobaglauca	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
3.	Barteriafistulosa	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
4.	Anogeisssusleiocarpus	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
5.	Garcinia kola	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
6.	Cola laurifolia	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
7.	Brideliaferruginea	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
8.	Uapacaguineensis	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
9.	Antidesmavenosum	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
10.	Parinarirobusta	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
11.	Cynometravogelii	Insoluble	Insoluble	Slightly	Slightly	Soluble

				Soluble	Soluble	
12.	Oncobaspinosa	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
13.	Dichopetalumbarteri	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
14.	Dichrostacyscinerea	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
15.	Pentaclethramacrophylla	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
16.	Tetrapleuratetraptera	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
17.	Stemonocoleusmicranthus	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
18.	Hymenocardiaacida	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
19.	Macarangahurifolia	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble
20.	Cordial millenii	Insoluble	Insoluble	Slightly Soluble	Slightly Soluble	Soluble

Qualitative determination of the phytochemical constituents of the wood samples

The presences of some phytochemical constituents of the wood samples weredetermined qualitatively. Results of the qualitative analysis are shown in the table 4 below. The qualitative examination of the woods reveals that although flavonoid was present in almost all the analysed woods, they were heavily present in *Antidesmavenosum*, slightly present in *Garcinia kola, Uapacaguineensis*, *Parinarirobusta* and absent in *Cynometravogelii* and *Oncobaspinosa.* Alkaloid was also present in almost all the analysed woods, except that it was absent in *Barteriafistulosa* ,slightly present in *Cola laurifolia, Antidesmavenosum* and *Oncobaspinosa.* Heavy presence of saponins were recorded for*Anogeisssusleiocarpus*, *Dichrostacyscinerea* and *Stemonocoleusmicranthus*whilesaponins were slightly present in *Brideliaterruginea, Antidesmavenosum, Parinari robust and Cynometravogelii*. Tannin was recorded to be heavily present *in Cola laurifolia, Uapacaguineensis, Dichopetalumbarteri, Tetrapleuratetraptera, Macarangahorofolia and Cordial millenii*and absent in*Barteriafistulosa, Parinarirobusta and Pentaclethra macrophylla.* Proteins were present in all the analysed woods but absent in *Brideliaterruginea* and *Antidesmavenosum.* Glycosides were also found to be present in all the woods but heavily present in *Caloncobaglauca, Tetrapleuratetraptera ,Cordialmillenii*and absent in*Anogeisssusleiocarpus* and *Cynometravogelii*. *Caloncobaglauca, Brideliaterruginea, Antidesmavenosum, Dichrostacyscinerea and Stemonocoleusmicranthus* showed heavily presence of Carbohydrate. Steroid was present in almost all the wood except in *Barteriafistulosa, Uapacaguineensis, Antidesmavenosum, Dichopetalumbarteri, DichrostacyscinereaandStemonocoleusmicranthus.*Absences of terpenoids were recorded only in *Pentaclethramacrophylla* while absence of *Phlobatannis* was recorded in almost all the woods except in *Barteriafistulosa* which was slightly present.

Table 4: Qualitative results of the Phytochemical Constituent of wood

Wood Sample	Flavonoids	Alkaloids	Saponin	Tannis	Proteins	Glycosides	Carbohydrate	Steroids	Terpenoids	Phlobatannis
Pycnanthusangolensis	+	+	+	+	+	+	-	+++	+++	-
Calonco baglauca	+	+	+	+	++	+++	+++	+++	+	-
Barteriafistulosa	+	-	+	-	+	++	+	-	++	++
Anogeissusleiocarpus	+	+	+++	++	+	-	++	+++	+	-
Garcinia kola	++	+	+	++	++	++	+	+++	+	-
Cola Laurifolia	+	++	+	+++	+	+	+	+++	++	-
Bridelia Terruginea	+	+	++	++	-	+	+++	+++	+	-
Uapacaguineensis	++	+	+	+++	+	++	-	-	++	-
AntidesmaVenosum	+++	++	++	++	-	++	+++	-	++	-
Parinarirobusta	++	+	++	-	+++	++	++	++	+	-
CynometraVogelii	-	+	++	+	+	-	-	++	+	-
Oncobas pinosa	-	++	+	+	+	++	+	++	++	-
Dichopetalumbarteri	+	+	+	+++	+++	++	++	-	+	-
Dichrostacyscinerea	+	+	+++	+	++	++	+++	-	+	-
Pentaclethramacrophylla	+	+	+	-	++	++	+	+++	-	-
Tetrapleuratetraptera	+	+	+	+++	++	+++	++	++	+	-
Stemonocoleusmicranthus	+	+	+++	+	+	++	+++	-	+	-

Hymeno cardiaaci da	+	+	+	++	++	+	++	++	+	-
Macaran gahorofo lia	+	+	+	+++	++	+	++	++	+	-
Cordial millenii	+	+	+	+++	++	+++	++	++	+	-

Key: Heavily Present = +++; Slightly Present = ++ ; Present = + ; Absent = -

Quantitative analysis of the phytochemical constituents of woods

(Table 5) shows the results of the constituents of different wood samples. It indicates the presence of tanin as high as 1180mg/100g for *Cola laurifolia* and as low as 650mg/100g in *Macarangahorofolia.* Alkaloids were found present in the wood samples which ranged between 14.2% in *Hymenocardiaacida* to 1.6% in *Barteriafistulosa*. Other phytochemicals that were present include Flavonoid (10.5 -1.8%) with *Antidesmavenosum*having the highest occurrence and *Barteriafistulosa*having the lowest value of 1.8%, Saponin was present in all the wood samples and ranged between 12.5 - 1.6%, oxalate ranged between 3.05 -0.38g/100g with *Cordial millenii* showing the greatest composition 3.05g/100g and *Antidesmavenosum* having the lowest composition of 0.38. The total acidity present in all the woods varied between 0.47 - 0.09g/100cm^3 with the highest composition in*Macarangahorofolia* and the lowest composition in *Cola laurifolia*. The cyanogenic glycoside, lipid and ash content were seen present between 891 - 336 mg/100g, 8.0 - 0.40 % and 3.5 - 1.0% respectively. Results from (Table 5) indicate that all the woods that were studied showed the presence of the phytochemical properties.

Table 5: Quantitative analysis of the Phytochemical Constituents of wood

Wood Sample (Botanic names)	Tannin (mg/100 g)	Alkal oid (%)	Flavon oid (%)	Sapon in (%)	Oxalat e (g/100 g)	Total Acidity (g/100c m^3)	Cyanoge nic glycoside (mg/100 g)	Lip id (%)	Ash Conte nt (%)
Pycnanthusango lensis	810	7.6	3.8	2.8	1.46	0.36	480	0.8	3.0
Caloncobaglauc a	720	5.2	3.0	4.0	1.78	0.3	842	4.8	3.5
Barteriafistulosa	680	1.6	1.8	3.0	2.78	0.38	713	1.2	2.0
Anogeissusleioc arpus	920	4.8	3.0	12.5	0.58	0.26	336	8.0	2.0
Garcinia kola	920	4.8	10	2.4	2.67	0.39	891	2.0	1.5
Cola laurifolia	1180	10.4	3.0	4.6	0.92	0.09	469	5.2	1.0
Brideliaterrugin ea	990	4.0	8.0	5.4	2.92	0.23	664	3.2	3.0
Uapacaguineens is	1120	8.0	9.2	4.4	0.8	0.24	697	4.8	3.0
Antidesmavenos um	1040	10.4	10.5	7.8	0.38	0.23	551	6.0	1.0
Parinarirobusta	750	6.4	8.0	5.4	1.25	0.26	664	6.4	2.5

Cynometravogelii	1220	7.6	3.0	7.6	1.36	0.12	356	1.6	1.5
Oncobaspinosa	850	9.8	3.0	4.0	2.36	0.18	648	4.4	1.5
Dichopetalumbarteri	1110	6.0	4.0	3.0	1.02	0.44	502	2.8	2.0
Dichrostacyscinerea	840	4.4	1.8	9.8	2.21	0.33	680	6.8	2.5
Pentaclethramacrophylla	690	6.4	4.0	4.4	1.6	0.34	891	4.0	2.0
Tetrapleuratetraptera	1090	4.0	4.4	3.6	1.73	0.17	859	1.2	3.5
Stemonocoleusmicranthus	760	11.6	8.0	4.6	1.12	0.3	324	5.2	2.0
Hymenocardiaacida	860	14.2	8.2	5.8	1.0	0.26	664	5.6	2.0
Macarangahorofolia	650	1.6	4.6	1.6	1.24	0.47	616	0.4	2.0
Cordial millenii	840	11.2	8.2	3.2	3.05	0.27	518	2.4	2.5

CONCLUSION

The tropical wood timbers studied contain chemical constituents that are essential to humans, pharmaceutical industries andother industries.

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