International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 11, November-2014

Synthesis on the Bubinga Wood Properties

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***Abstract*— This article presents a synthesis of the properties of Bubinga. It should be recalled that the name Bubinga is the commercial term used to refer to four tree species of which the most common are the Guibourtia Demeusei and the Guibourtia de Tessmannii. A brief description of both species and their geographical location is provided in the study. From the general analysis of the physical, chemical and mechanical properties of the Bubinga which vary slightly from one type to another, one notices that: as concerns the chemical aspect, the Bubinga is made up of less than 40% of cellulose, it is less siliceous (below 1%) and has an acid ph. From a physical and mechanical point of view, the wood is thick, stable with a high mechanical strength. To all these qualities, one has to add its aesthetic properties that make it to be as widely** used **as shown in this paper.**

Keywords—Bubinga, Guibourtia Demeusei, Guibourtia Tessmannii, pH, resistance.

I. INTRODUCTION

Bubinga is both a commercial expression and a tree used to refer to species such as the Guibourtia Demeusei and Tessmannii which are scattered in equatorial Africa within an area stretching from South Nigeria to the Congo. It produces hard and dense wood whose exceptional aesthetic qualities and stability are highly appreciated by professionals in the wood industry. Given its varied uses, and in light of our tests and studies found in the appropriate literature, our aim is to carry out a synthetic study on the physical, chemical, and mechanical properties of this species

II. TREE DESCRIPTION

The Bubinga is a tree that is generally found in Equatorial Africa ([1], [2], [3], [4]). Originally called Buvenga by the Mitsogho tribes in Gabon, it is part of the Caesalpiniaceaes family that include about fourty botanical species. The Bubinga is also a trade name used to refer to the following four species:

the Guibourtia Tessmannii or Pink Bubinga;
the Guibourtia Demeusei;
the Guibourtia Pellegriniana;
the Guibourtia sp.

Out of these four species, we will focus only on the two most exploited species: the Guibourtia Demeusei and the Guibourtia Tessmannii.

A. The Guibourtia Demeusei

This species is found in periodically flooded forests, located along river banks and coastal zones. The tree (Figure 1), that can be as high as 40m, has a few straight, slim high and 45° inclined buttresses [2]. The straight and cylindrical bole can be up to one meter in diameter. The bark, whose thickness varies between 0.5 to 1.00cm, is soft and grey in younger trees, then rough in older ones. When cut, the bark shows a grainy red edge through which one can see sharp red wood. The Guibourtia Demeusei foliage is quite dense, and made up of alternate leaves of a single pair of leaflets, slightly opposed and slightly curved. These leaflets are bigger than those of the Guibourtia Tessmannii (Figure 2), The limb in young leaves is riddled with numerous spots that become nearly invisible as they grow older [1]. The fruits produced by the Guibourtia Demeusei are two-valve tough pods, sharply striated with a slight mucro laterally marked downwards with short pedicles.

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Fig. 1. Bole of Guibourtia Demeusei

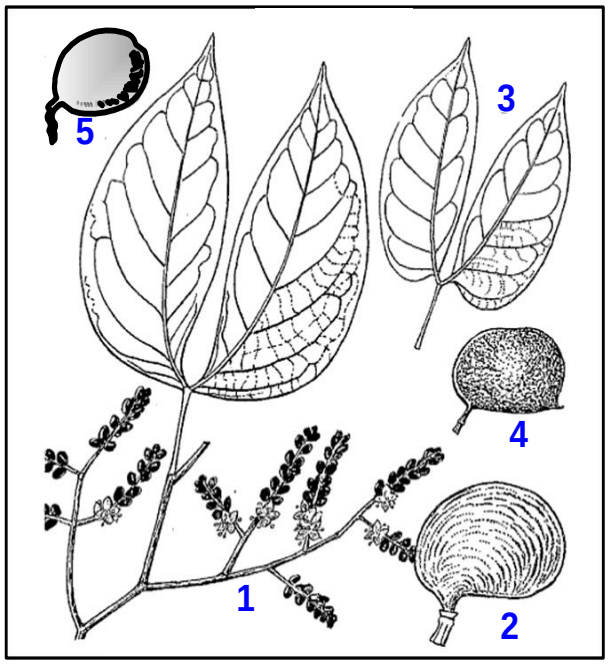

Fig. 2. Leaves of the Guibourtia. Guibourtia Tessmannii 1, leaves 2, fruits Guibourtia pellegriniana: 3 leaves 4, fruit of Guibourtia Demeusei 5[1].

B. *The Guibourtia tessmanniis*

It is found in the primary forest of the Atlantic coast of Central Africa and in South Nigeria. The tree can be as tall as 60 m and has at its base slim, irregular and tortuous buttresses[1]. The straight and cylindrical bole can be as high as about 30 m with a 3 m diameter. Bigger trees often have misshapen and channelled boles. The Guibourtia Tessmannii's crown is generally large and made up of upright branches with dense foliage. Its bark is soft in younger trees and rough in older ones. Its colour is brown red and of rough aspect; it is 1 cm thick and exfoliates in small circular chips that reveal sharp red vacuums. A cut in the bark shows a dark grainy pink edge exuding blood red gelatinous gum. The sapwood, that is clearly different from the core wood is thick and whitish, and is often attacked by insects and fungi. The wood is hard, less siliceous, less fissile, and its colour varies from pink brown to reddish, has fine purplish-blue red grains [2]. The leaves (Figure 3) are made up of single, opposed, sessile and slightly curved pointed-edged leaflets. Their dimensions are 7-17 x 3-6 cm and their leafstacks 1.5 – 3.5 cm. the fruits are two-valve hard small pods whose surface is sharply wrinkled and striated, and whose dimensions are as follow: 3-3.5 x 2-2.5 cm. There are 1 to 2 seeds entirely rounded with an aril [1].

Fig. 3. Trunk and foliage of the Guibourtia Tessmannii [1].

III. GEOGRAPHICAL LOCAL

It is worth noting that Cameroon and Gabon are the main producers of Bubinga wood.

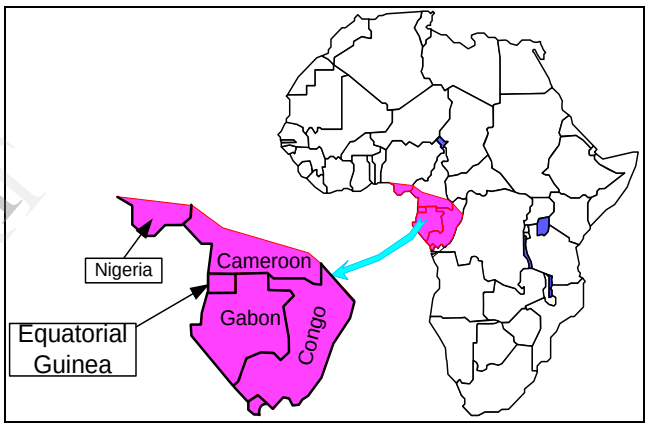

Fig. 4. Geographical local of Bubinga

A. *The Guibourtia tessmannii*

It is found in primary forests and stable land of the coastal zone (Figure 4) stretching from the South of Nigeria to the South of Mayombe (Democratic Republic of Congo). Its name varies according to the area where it is found. In south Cameroon for instance, the Bassas call it Simingan, the Fang (Bulus) Oveng, the Ewondos; Essingang. In Gabon, the Fang call it Oveng, the Nkomis; Kevazingo, the Mitsoghos; Buvenga. In the Democratic Republic of Congo, it is called Waka, and in Congo, the Lianus call it Kiombe.

B. *The Guibourtia Demeusei*

In Cameroon, it is found in the Douala and Kribi coastal zone, in the East along the banks of the Ngoko and Sangha rivers as well as in most Central African countries such as Equatorial Guinea, Gabon, Congo and the Central African Republic. Its name varies according to the area where it is found. In Gabon, the Fang call it Ebana, in Congo and in the Central African Republic, it is called Paka. In Cameroon, the Bagialli Pygmies call it Mbaya, and those from Bibaya refer to it as Paka. In Equatorial Guinea, the Fang call it Oveng.

IV. WOOD CHARACTERISTIC AND STRUCTURE

A. *Logs features.*

Bubinga logs (Figure 5) whose diameter is less or equal to 90 cm are cylindrical and more or less straight. On the contrary, those with a large diameter have a faulty shape due to various deformations. For instance butt logs often display some flutes due to the presence of buttresses at the base of the bole. At the edges of logs, the colour of wood is dark brown with slightly visible rings. The sapwood, which is different from core wood, is 7-8 cm thick. The core is generally well-centred with generally slight cracks. The diameter of logs varies between 60 and 200cm.

Fig. 5. Bubinga log.

B. *Wood aspect*

Fig. 6. Aspect of Bubinga sawn wood.

Fig. 7.

Heartwood is pinkish dark brown or reddish in colour, slightly veined and at times with entangled fibres. This is why it is referred to as figured wood. Irregular coloured and quite close grains are more or less pronounced according to origin. While the Guibourtia pellegriniana produces wood with finer texture and less pronounced grain than the Guibourtia tessmannii, the Guibourtia Demeusei on the contrary produces wood with a sharper violet red colour than the top previous species, and whose grain is similar to that of the Guibourtia Pellegriniana.

C. *Wood structure (Figure 7)*

The parenchyma which can be seen through a magnifying glass is associated with slightly stretched mantle-like pores, anastomosed or not. At maturity, it forms a straight line; some chains of crystals are often found in re-compartmentalized cells. Pores are quite well visible, rare (1 to 3 per sq.mm2 in the Guibourtia Tessmannii and G. Pellegriniana), and often isolated, at times clustered in 2 or 3. Their size varies between about 150 to 220 µm. At times, they are obstructed by whitish deposits. The diameter of intravascular pits is about 7 to 9 µm. The rays, which are quite numerous, have a width of about 3 to 5 cells and their structure is quite homogenous. Fibers are about 1800 µm long and 25 µm large. Their flexibility coefficient varies between 55 and 60. The Guibourtia Demeusei has vessels of the same diameter, but in greater number (4 to 10 per mm2) than those in the Guibourtia Tessmannii and Pellegriniana.

Fig. 8. Microscopic Structure of the Guibourtia Tessmannii:and-grain cutting [1].

V. CHEMICAL PROPERTIES

A. *Chemical composition*

The compilation of bibliographical results shows us that the chemical composition of the Bubinga varies very slightly from one species to another and the percentage of celluloses is lower than 40%. This conclusion is further confirmed by the works of [2] (Table 1) that carried out tests on four wood samples including two from Gabon (Guibourtia tessmannii et sp), one from Cameroon (Guibourtia tessmannii) and one from the Central African Republic (Guibourtia Demeusei) [2].

TABLE I.

OMPOSITION CHIMIQUE DU BUBINGA[2].

Constituents	Number of sample trees	Average (in % dry wood)
alcohol-benzene Extract	4	4.25
Boiling water extract	4	2.35
Pentosans	4	20.7
Cellulose	4	39.2
Lignine	4	28.75
Total dusts	4	0.65
Silica	18	0.to1

B. *The pH of dry Bubinga*

The efficient use of wood entails the knowledge of its pH that plays an important role in the gluing, the lamination and the varnishing, due to reactions that can occur at the surface of wood. Samples used including the Guibourtia Demeusei, the Guibourtia Tessmannii and the Frake are all from Cameroon. We measured the pH of the Bubinga and Frake in the CIRAD-Forêt laboratory in Montpellier, France according to the following procedure: Bubinga wood is reduced into powder in a machine called breaker. Five grams of this powder are put into a 100 ml bowl and 50 ml of mineralized water. The mixture is brought at boiling point and maintained at that temperature for 30mn, then cooled. When the temperature falls to 20°C, a pH-meter is introduced to indicate the pH according to temperature. Results obtained are summarized in Figure 8 and Table 2, and show that unlike Frake, Bubinga is an acidic wood.

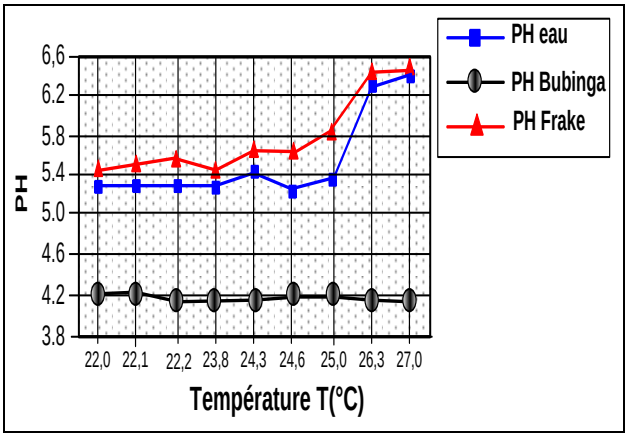

Fig. 9. Evolution of the pH for Bubinga and Fraké according to temperature.

TABLE II.
PH FOR DU BUBINGA AND FRAKE.

Temperature	22 °C	22.1 °C	22.2 °C	23.8° C	24.3 °C	24.6 °C	25.0 °C	26.3 °C	27.0 °C
Water PH	5.30	5.30	5.30	5.28	5.45	5.25	5.36	6.3	6.4
Bubinga PH	4.17	4.19	4.14	4.15	4.16	4.16	4.16	4.14	4.14
Frake pH	5.46	5.51	5.57	5.44	5.65	5.64	5.85	6.45	6.45

VI. PHYSICAL AND MECHANICAL CHARACTERISTICS

Bubinga, which becomes stable at a moisture rate situated between 10 and 12.5% is a stable species; well dried and used, variations in dimensions due to climatic variations are negligible and cause no deformation

A. *Physical characteristics*

The compilation of all bibliographical ([1], [2] [5]), results summarized in Table 3 reveal that physical characteristics vary little irrespective of the species studied. Bubinga is a thick type of wood given that its density at 12% moisture varies between 0.8 and 0.95 with an average of 0.92. It belongs to the category of very hard wood, since the hardness obtained according to the Chalais Meudon method at 12% moisture rate is between 7.7 and 14.8 with an average of 9.8. It has an average retractability because its volumic, tangential and radial shrinkages are moderate (0.63%, 8%, and 5.2%).

TABLE III.
PHYSICAL CHARACTERISTICS OF BUBINGA AT 12% MOISTURE [2], [2] AND [5].

	Density at 12% moisture	Hardness as per Chalais Meudon	Retractability		
			Volumic Shrinkage (%)	linear Tangential shrinkage T(%)	Linear Radial Shrinkage R(%)
Min value	0.88	7.7	0.5	6.5	4.0
Max Value	0.95	14.8	0.85	10.5	7.5
Average value	0.92	9.8	0.63	8.0	5.2
Class	Heavy	Hard	Average	Average	Average

B. *Mechanical features*

The compilation of bibliographical results on mechanical characteristics of the Guibourtia Demeusei and tessmannii which are summarized in Table 4 tends to indicate that irrespective of the species considered, mechanical characteristics are high and homogenous.

TABLE IV.
ECHANICAL CHARACTERISTICS OF BUBINGA AT 12% [1], [2] AND[5].

	Transverse cohesion			**Axial cohesion in MPa**		
	Splitting ⊥ in daN/cm	Traction ⊥ on fibres (MPa)	Shear (MPa)	Compression (MPa)	Static flexion (MPa)	
				R_C	R_f	Elasticity Module E
Min. Value	19.3	3.81	9.3	69.5	100	13.010^3
Max Value	26.7	4.92	16.1	79.1	215	20.810^3
Average value	23.1	4.42	13.0	75.0	150	16.410^3

.*Resistance to compression*

Bubinga has a strong compression to resistance (with an average value of about 75 MPa). This resistance to compression which is determined for a 12% moisture rate is equal to the shear to apply parallel to fibres in order to cause the compression of a test glass with a 4 cm2 section and 6 cm length.

C. *Resistance to static flexion*

Resistance to static flexion is strong (150 MPa average value), and corresponds to the shear to apply to a 34x2x2 cm test tube to get to breaking point when it is on two 28 cm stands[5].

VII. DURABILITY, PRESERVATION AND USES

A. *Durability and preservation*

Experience acquired in this field shows that except the sapwood whose hardness is limited, Bubinga wood resists well to attacks from biological agents fungi, termites, lyctus, capricorn beetle). It can be well preserved and very resistant to rotting and xylophageous insects

B. *Drying*

In conformity with the result of [1] and [2], dried in free air, Bubinga presents neither crack nor deformation. But artificial drying seems to be slow, although risks of cracks and deformations are quite low. One has to remember that the drying of 55 cm thick Bubinga planks under free air up to 16 to 18% moisture may take up to 15 weeks.

C. *Processing*

Due to its hardness, Bubinga should be sawn with equipment that is strong and powerful enough, despite its low content in silica (Table 1) it usually causes the wear of the type of steel commonly used for the fabrication of band mills. In spite of its hardness, Bubinga can be planed down, routed, turned, and surfaced with quick steel equipment ([1], [2]).

D. Uses

Due to its high hardness, Bubinga is difficult to join through traditional means – nails get bent and screws drive into it with difficulty. To overcome this difficulty, it is indispensable to make pilot holes. Although its gluing is delicate and needs a lot of care, Bubinga can be easily painted and varnished to take a very beautiful polish due to its fine grain that gives a very nice aspect. Given these aesthetic and stability qualities, Bubinga is an excellent wood for cabinetwork and decoration that produces fine grained and generally watermarked rich veneers used for furniture, pianos, marking and stylish furniture. As solid wood, it is used for the manufacturing of office equipment, knife and brush handles, carvings, cross ties for railways etc. It is also used for the construction of heavy roof framings, wagon floors and furniture (seats and other furniture). It produces very beautiful stairs and floorings. Processing produces waste such as logs, slabs, edgings, chips and sawdust. These wastes can also be used as fuel or as raw material in the production of reconstituted wood. They can also be used as aggregates in the production of wood concrete.

VIII. CONCLUSION

Bubinga is a tree belonging to the Caesalpiniaceaes family. It is also a trade name used to refer to the Guibourtia Demeusei and tessmannii. Its less siliceous wood is dense, stable with low acid pH. In addition, its high mechanical characteristics and its exceptional aesthetic qualities make Bubinga wood to be highly appreciated and has a wide range of use in carpentry and cabinetwork, in spite of the high level of ware it has on equipment. Processing produces wastes that are excellent fuel, and some of which, such as chips and sawdust can be used in the production of wood concrete or reconstituted wood.

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