World Engineering & Applied Sciences Journal 11 (1): 21-25, 2020
ISSN 2079-2204

DOI: 10.5829/idosi.weasj.2020.21.25

Physical and Mechanical Properties of *Anogeisus leiocarpa* (CD) and *Commiphora africana* (A. Rich) as Potential Timber Trees for North Darfur State (Sudan)

[1]*Osman Taha Elzaki,* [2]*Mohamed Elsanosi Adam Habib and* [3]*Tarig Osman Khider*

[1]Institute of Engineering Research and Materials Technology, NCR, Khartoum, Sudan
[2]University of Al Fashir, Faculty of Environmental Sciences and Natural Resources
[3]University of Bahri, College of Applied and Industrial Sciences

Abstract: Physical and strength properties of Sudanese *Anogeisus leiocarpa* (CD) Gill and *Commiphora africana* (A. Rich.) wood from North Darfur State were studied to determine their physical and mechanical properties as potential wood species for North Darfur State and Sudan. Moisture content, wood density (basic and oven-dry), Bark-to-wood ratio by volume and radial and tangential shrinkage were determined. Static bending strength, compression strength parallel to the grain, the modulus of elasticity (MOE), the modulus of rupture (MOR) and the maximum crushing strength for both wood species were determined. The obtained results have shown low values of moisture content for both wood species due to the relatively low humidity during summer when they were collected. *A. leiocarpa* has shown a higher average value for oven-dry density (861.0 kg/m^3) *while Commiphora africana* has shown a lower oven-dry density (261.0 kg/m^3). The average bark-to-wood ratio was found to be higher for *C. africana* (10.23, %) than *A. leiocarpa* (7.52%). They were all in the normal range for tropical hardwoods. The tangential shrinkage for both wood species was almost double the radial shrinkage. The ratio for tangential to radial shrinkage (T/R) was higher for *A. leiocarpa* (2.20) and lower for *C. africana* (1.58). Those properties, in addition to the highest maximum crushing strength make *A. leiocarpa* a suitable wood for structural works and furniture. *C. africana* was found to be very brittle during static bending and compression tests. Due to its strength properties it is not suitable for construction or any uses which need strength.

Key words: *Anogeisus leiocarpa* · *Comiphora africana* · Basic Density · Static Bending · Compressive Strength

INTRODUCTION

Hardwood species have different properties depending on wood anatomy and chemical composition affecting the mechanical properties of wood and utilization in wood industries especially furniture and pulp and paper [1-5].

North Darfur State in Sudan, has its own natural vegetation including some important trees and shrubs among which are; *Anogeisus leiocarpa* (Sahab) and *Commiphora africana* (Gafal). *Anogeisus leiocarpa* (DC) Guill. & Perr. Is a tall deciduous tree belongs to the family *Combretaceae* Batawella, *et al*. [6]. It is known in Arabic as Sahab and in English as African birch. It is found in most countries of the Sahil from Senegal to Sudan and Ethiopia [7, 8]. In Sudan it is found in Jebel Marra, Kasala, Kordofan, Southern Darfur and North Darfur State (Kabkabia Province). This tall deciduous tree reaches up to 30 meters high. It has a grey yellowish scaly bark. It has a valuable timber yellowish to light grey in color (Figure 1) while the heartwood is dark brown to nearly black. The wood is relatively durable and resistant to termites and wood-destroying insects. The wood is suitable for many uses such as construction, furniture and poles [9]. In West Africa, the leaves are used in traditional dyeing process of cotton textiles known as "Basilan" [10]. The bark and leaves are used in traditional medicine [9, 11, 12]. The extracts of leaves, stem and root bark were found to have an antimicrobial effect on infectious wounds.

Corresponding Author: Tarig Osman Khider, University of Bahri, college of Applied and Industrial Sciences, Sudan.

Fig. 1: *Anogeissus leiocarpa* wood and bark

Fig. 2: *Commiphora africana* wood and bark

Commiphora africana (A. Rich.) Engl. is a deciduous small tree belonging to the family *Burseraceae*. It is commonly known as (African myrrh) and in Sudan it is known as (Gafal). It is widely distributed in sub-Saharan Africa including Sudan, Chad, Ethiopia, Eriteria, Kenya, Senegal, South Africa and Somalia. On sandy soils this species sometimes forms pure stands. This small tree usually ranges between 3 to 5m high. Sometimes reaches up to 10 meters [7]. The bark is grey-green, peeling to reveal a shiny surface when damaged and then exuding bdellium which is a clear edible aromatic gum (Figure 2). The leaves are trifoliate with a large terminal leaflet and two small side leaflets. The tree is used for live hedges. The fruits are used for typhoid fever and stomach problems. The bark is used for treatment of malaria and the resin is used for wonds and as an insecticide. The wood is light [13] and resistant to termites and used for curving as well as domistic utensils and musical instruments.

The use of these wood species is restricted to fuel wood and charcoal as well as some traditional buildings. In order to make the best utilization of these wood species, this study was carried out aiming at the investigation of the physical and mechanical, properties of both two indigenous hardwood species in order to provide information relating to wood properties which lead to the best utilization of these local hardwood species.

MATERIALS AND METHODS

Materials: The materials used in this study were samples from two Sudanese hardwood species collected from North Darfur State. Those two hardwood species were *Anogeissus leiocarpa* (Sahab) from Kabkabia province and *Commiphora africana* (Gafal) from Al Fashir Province. The wood of *C. africana* is yellowish white as shown in (Fig. 1) and the wood of *A. leiocarpa* is yellowish brown as presented in (Fig. 2).

Wood samples from the two species were prepared and reduced into testing specimens according to the British standards B.S. [14].

Moisture Content: Moisture content of wood was determined using a sensitive balance and an oven maintained at 105°C. The specimens were dried to constant weight. The moisture content was calculated as follows:

$$M.C\% = \frac{A-B}{B}\% \qquad (1)$$

where: A = Air - dry weight of specimen, B = Oven-dry weight of specimen, M.C. = Moisture content.

Wood Density: Wood density was carried out using water displacement system. The basic density was determined as oven-dry weight / green volume, while the oven-dry density was determined as oven-dry weight / oven-dry volume. Both oven-dry density and basic density were calculated by the following equations:

$$Oven-dry\ Density = \frac{oven-dry\ weight}{oven-dry\ volume} kgm^{-3} \qquad (2)$$

Bark-to-wood Ratio: Bark-to-wood ratio was determined as a proportion of the whole tree (including bark) both by volume and by mass. Wood discs (2.5 cm thick) were cut, weighed and dried to constant weight in an oven at 105°C. The bark and wood were weighed separately and from their masses the percentage of bark was calculated based on the oven-dry mass of the original test sample as follows:

$$Basic\ Density = \frac{oven-dry\ weight}{oven-dry\ volume} kgm^{-3} \qquad (3)$$

Wood Shrinkage: Wood shrinkage was determined using wood specimens of 2 cm x 2cm x 2 cm Measured with a Vernier caliper. The specimens were left to dry in an oven until constant weight, then they were measured again and the difference in dimensions was calculated as shrinkage ratio as follows:

$$Bark-to-wood\ reatio=\frac{mass\ of\ oven-dry\ bark}{mass\ of\ oven-dry\ wood} \quad (4)$$

Bending Strength: Static bending tests were carried out using a universal testing machine Specimens of 2cm x 2cm x30cm size were supported over a span of 28 cm on the roller bearings. The load was applied to the center of the beam at a speed of 0.01 mm / second. The modulus of elasticity and the modulus of rupture were recorded (add reference).

Compression Strength: Compression strength parallel to the grain was carried out using specimens of 2cm x 2cm x 6cm size. The test was carried on a universal testing machine. The load was applied to the piston of the cage at a rate of 0.01mm per second. The maximum crushing strength (Pmax) was calculated by dividing the load to failure by the cross sectional area of the specimen as shown in the following equation:

$$Shrinkage\% = \frac{change\ in\ dimension\ from\ swollen\ size}{swollwn\ dimension}\times 100 \quad (5)$$

where: P_{max} is the maximum load at break point (kpa), A = the area of the cross section of the specimen.

RESULTS AND DISCUSSION

Physical and Morphological Properties: The mean values of physical properties for *A. leiocarpa* and *C. africana* from North Darfur state are shown in Figure 3. The values of moisture content for both wood species were nearer to each other (4.64% for *A. liocarpa* and 4.43 % for *C. africana*). In general the average values of moisture content for the two wood species under study were considered low. This may be due to low relative humidity of the surrounding atmosphere during summer when the samples were collected.

The average oven-dry and basic density of wood for the two species is shown in Figure 4. The oven-dry density for *A. leiocarpa* (861.0 kg m^{-3}) was higher than that for C. *africana* which has shown very low oven-dry density (261 kg m^{-3}). The same respect was shown for the values of basic density (777.0 kg m^{-3} for *A. leiocarpa* and 229 kg m^3 for *C. africana*. The values of basic density were lower compared with those of oven-dry density. That was due to the bigger volume (green volume) of specimens at the fiber saturation point [15]. Since the wood density is a characteristic of wood that affects the properties of the manufactured products, it could be taken as a reasonably reliable indicator of the wood strength and ease of working.

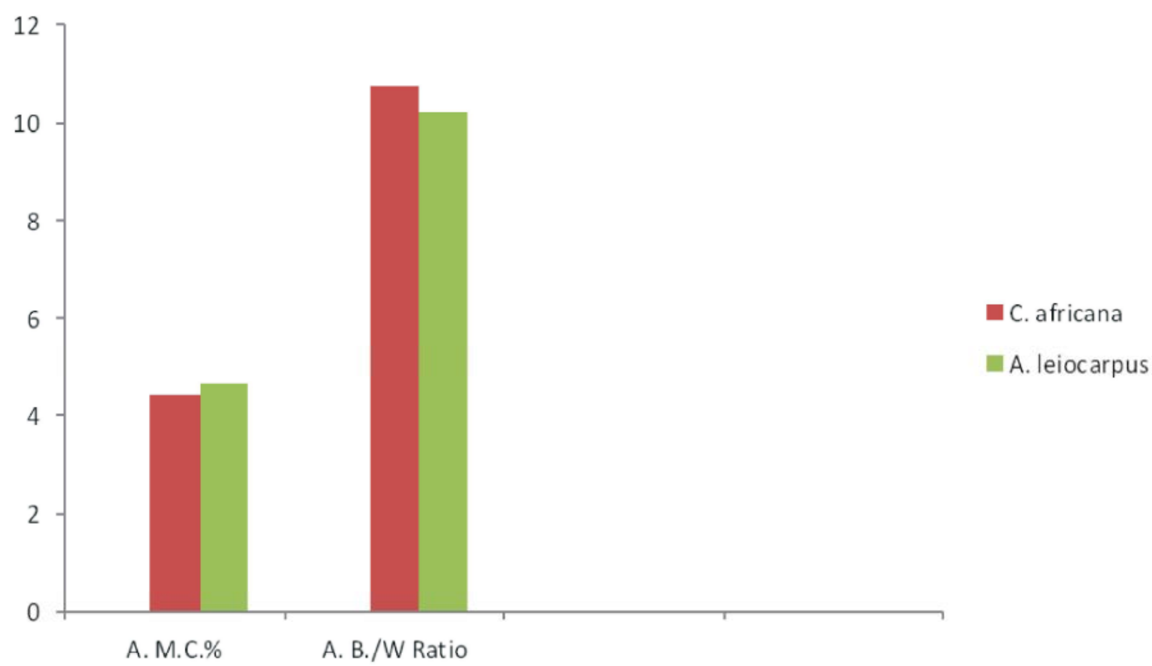

Fig. 3: A histogram showing the average moisture content and bark-to-wood ratio for *A. leiocarpa* and *C. africana* from North Darfur State (sudan)

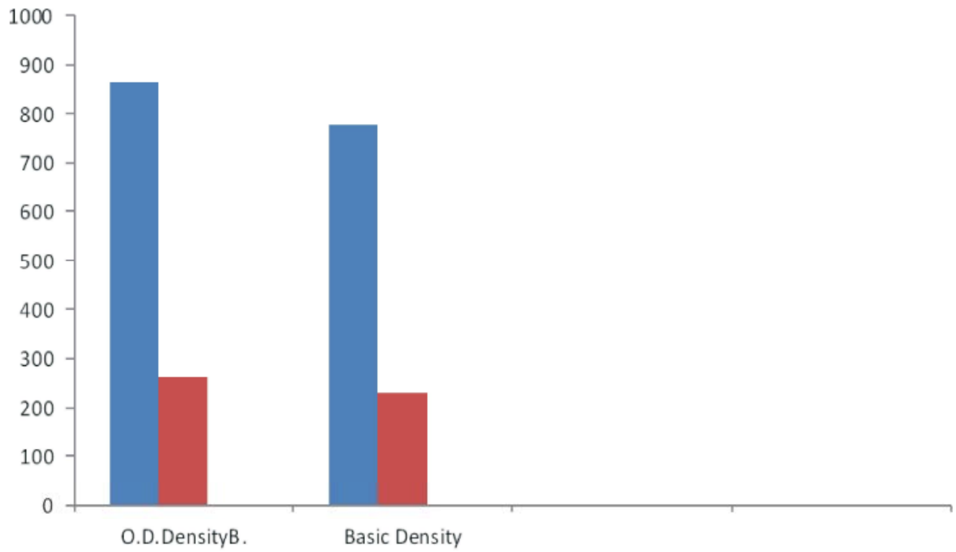

Fig. 4: The average values for oven dry density and basic density for A. *leiocarpa* and *C. africana* from North Darfur State

Table 1: Average Radial and Tangential Shrinkage ratio for *A. leiocarpa* and *C. africana* from North Darfur State

Species	Radial shrinkage %	Tangential shrinkage %	Shrinkage ratio T/R
A. leiocarpa	3.72	8.23	2.20
C. africana	2.83	4.46	1.58

Table 2: The results of static bending tests showing average modulus of rupture and modulus of elasticity for *A. leiocarpa* and *C. africana* from North Darfur State (Sudan)

Species	P_{max} (kN)	MOR MPa cm^{-2}	MOE kPa cm^{-2}
A .leiocarpa	2.989	135.890	14295.020
C. Africana	0.783	29.523	3577.554

Table 3: The average values for compression strength parallel to the grain for *A. leiocarpa* and *C. africana* from North Darfur State

Species	P_{max} (kN) Minimum	P_{max} (kN) Maximum	P_{max} (kN) Average
A. leiocarpa	32.690	36.520	33.202
C. africana	08.100	16.300	11.178

The average value of bark-to wood ratio for *C. africana* (10.75 %) was a little bit higher than *A. leiocarpa* (10.23 %). The ratios for are nearer to each other and they are in the normal range for tropical hardwoods.

The tangential shrinkage (Table 1) for both two wood species was almost double the radial shrinkage, with the higher value for *A. leiocarpa* (8.46%) and lower value was for *C. africana* (4.46 %). This is the same as cited by Elzaki *et al.* [15] Panshin and De Zeeuw [16] and Desh [17], The ratio for tangential to radial shrinkage (T/R) was higher for *A. leiocarpa* (2.20) and lower for *C. africana* (1.58).

Mechanical Properties: Table (2) shows the average values of the modulus of elasticity and modulus of rupture for the two wood species studied due to static bending tests. The highest values for the modulus of rupture (MOR) and the modulus of elasticity (MOE) were those for *A. leiocarpa* (135.890 MPa and 14295.020 kPa), while the lowest values were those for *C. africana* (29.523 MPa and 3577.554kPa, respectively). This variation may be due to the difference in the anatomical structures and mainly to indicators such as fiber length and cell wall thickness as well as an important physical parameter such as the wood density [10]. Table 3 shows the results of compression strength parallel to the grain for the two wood species under study. The highest average value was that for *A. leiocarpa* (33.202 KN). *C. africana* has shown a lower value (11.178 KN). This may be due to the same factors influencing bending and other mechanical properties of both wood species. Due to the observations from the bending tests *C. africana* was very brittle during the bending and compression tests.

CONCLUSION

From the physical and morphological results and in addition to the highest MOE and MOR as well as the maximum crushing strength, *A. leiocarpa* could be considered as a good structural timber which is suitable for structural works and furniture. *C. africana* was found to be very brittle during static bending and compression tests. Due to its lower density and strength properties, it is not suitable for construction or any uses which need strength. It could only be used for light works such as match manufacturing, boat making and light tool handles.

REFERENCES

1. Mangasha, L.A., 2019. Review on Effect of Some Selected Wood Properties on Pulp and Paper Properties. Journal of Forestry and Environment, 1(2): 16-22
2. Mussa, M. and T. Bekele, 2019. Within-Stem Variations in Density and Mechanical Properties of *Acacia melnoxylon* R.Br Grown in Chencha, Southern Ethiopia. Journal of Forestry and Environment, 1(1): 01-15.
3. Khider, T.O., S.H. Omer and O.T. Elzaki, 2012. Pulping and Totally Chlorine Free (TCF) Bleaching of Acacia mellifera from Sudan. World Applied Sciences Journal, 16(9): 1256-1261.
4. Khider, T.O., R.S. Himet, I.M. Sulieman, S.H. Omer, O.T. Elzaki, S.D. Mohieldin and S.K. Shomeina, 2020. Soda Anthraquinone Pulping of Sudanese Maerua crassifolia (Sarah) Wood. European Journal of Applied Sciences, 12(1): 25-31.
5. Khider, T.O., M.M. Hamza, S.H. Omer, O.T. Elzaki, S.D. Mohieldin and S.K. Shomeina, 2020. Application of Soda Anthraquinone Pulping to Sudanese Albizia amara (Arad) Wood. African Journal of Basic & Applied Sciences, 12(1): 06-12.
6. Batawila, K., K. Kokou, K. Koumaglo, M. Gbeassor, B. De Foucault, P. Bouchet and K. Akpagana, 2005. Antifungal activities of five *Combretaceae* used in Togolese traditional medicine. Fitoterapia, 76(2): 264-268.
7. Maydell, H. and J. Von, 1990. Trees and Shrubs of The Sahel: Their Characteristics and Uses. GTZ Verlagjosefmargraf Scientific Book.
8. El amin, M.H. , 1990. Trees and Shrubs of the Sudan. Ithaca press, UK, pp: 484.
9. Adamu, A.M., O.A. Ushie and A.H. Gwangwala, 2013. Estimation of Flavonoids and Tannins in the stem, bark and leaves of *Anogeisus leiocarpa* plant. International Journal of Traditional and Natural Medicine, 2(3): 141-148.
10. Baja, Y., 1988. Medicinal and Aromatic Plants. In: Biotechnology in Agriculture and Forestry, pp: 24.
11. Abdullahi, M., Y. Yasmin, B. Aderotimi and G. Ajayi, 2008. Phytochemical and antibacterial screening of *Anogeissus leiocarpus* against some microorganisms associated with infectious wounds. African Journal of Microbiology Research, 2(3).
12. Govindarajan, R., M. Vijayakumar, C.V. Rao, A. Shirwaikar, A.K. Rawat, S. Mehrotra and P. Pushpangadan, 2004. Antioxidant potential of *Anogeissus latifolia*. Biological and Pharmaceutical Bulletin, 27(8): 1266-1269.
13. Carsan, S., C. Orwa, C. Hardwood, R. Kindant, A. Strobel and R. Jamnadass, 2012. African wood Density data base. World Agroforestry Center, Nirobi.
14. B.S. 373 1957. The British Standard Methods of Testing Small clear Specimens of Timber. British Standards Institute, London.
15. Elzaki, O.T., S. Otuk and T. Khider, 2013. Strength Properties of *Crateva adansnii* from Sudan. Journal of Forest Products & Industries, 1(1): 23-26.
16. Panshin, A.J. and C. De Zeeuw, 1980. Textbook of Wood Technology 4th ed. McGraw Hill Book Compamy, New York.
17. Desch, H.E. and J.M. Dinwoodie, 1996. Timber, Structure, Properties, Conversion and Use. ^{7th} ed. Macnillon Press, London, UK, pp: 306.