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Influence of age and trunk positions on physicomechanical properties of *Anthocleista grandiflora* Gilg wood

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ABSTRACT

Population growth and the high demand for the use of wood already consolidated on the market have caused a high demand for forestry resources. This factor motivated the search for other species with properties that satisfy everyday needs in industrial applications. The research aims to characterize the physical-mechanical properties of *Anthocleista grandiflora* wood. Samples were taken to determine the properties of the three trunks' base, middle, and top regions at 38, 43, and 47-year-old. Physical (density, moisture content, and volumetric increase) and mechanical tests (flexural strength, elasticity resistance, shear strength, and Janka hardness) were used to characterize the material. The results confirmed that the lowest average moisture content was presented at the base of 38-year-old trees, with values varying from 12.2 to 13.3% in the heartwood and sapwood regions. For density, the base of 47-year-old trees obtained the highest values, with a variation of 434.3–477.3 kg m^{-3} in the heartwood and sapwood regions. Mechanical flexural strength tests demonstrated that the highest value for the modulus of rupture was 63 MPa, indicated by samples taken from the heartwood of 43-year-old trees. The results show that *A. Grandiflora* wood can be used for various value-added purposes (construction, furniture, and other equipment).

Keywords: Wood quality; Dimensional stability; Hardness; Static bending.

1. INTRODUCTION

Wood continues to be an imperative material in the history of humanity because of its exceptional features and broad utilization spectrum, and it has remained the most multipurpose construction material for decades [1]. ARRIAGA *et al.* [2] emphasized that wood has remained a structural material for ages, ever since its discovery as an accepted renewable resource material by humankind. As the human population soars, there is an increasing demand for wood-based construction products and artifacts. However, the increased desire for wood-based materials for the rising human population has dramatically burdened forest resources. Hence, ASAFU-ADJAYE [3] acknowledged that the wood request is rising at a disturbing frequency such that the Yearly Permissible Censored (YPC) of one million m^3 is inadequate. The yearly taking-out logs by wood processing companies are evaluated at approximately 3.7 million m^3. Entirely several people have decided that the forest ought not to be garnered. However, humanoid statistics and ingesting continue to upsurge [3].

These bases referred to above are the challenges for forest management; thus, they need help coming up with the request of timber processing firms, compelling wood processing companies to shut down. The state and global request for a few principal species has led to their perilous abuse. Even though several other wood types, known as lesser-known and lesser-used, stand barely in use, the reason is that their technological properties still need to be completely strong-minded [3]. According to QUARTEY [4], unknown

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(or lesser known) species (LKS) and wood classes without comprehensive perspective have hitherto not been used. In their study, KABA *et al.* [5] pointed out that lesser-known or lesser-used species need better and immediate observation of their application, a substitute for the principal wood species to upsurge the wood supply base. According to AGUMA and OGUNSANWO [6], the degradation of the tropical high forest through illegal harvesting and misuse of timber has affected the forest ecosystem, causing its depletion. Thus, DADZIE and AMOAH [7] emphasized that Africa's significant commercial tropical hardwood species are threatened with extinction due to over-dependence. JACKSON and ADAM [8] explain that although the species *Anthocleista grandiflora*, *Syzygium guineense*, and *Macaranga kili-mandscharica* are not under threat of extinction, the high volume of extraction carried out irresponsibly could put the existence of these trees in danger.

The wood industry needs more raw materials [6]. They are exploring the public perception of using (LKS) or Lesser-Used Species (LUS) to make furniture to save our dwindling forest [9]. Hence, the effective and efficient utilization of Lesser-Known Species (LKS) will contribute to achieving the Sustainable Development Goals (SDG #15). SDG #15 target #2 advocates for the sustainable management of all types of forest resources and particularly supports a sustainable increase in biodiversity conservation programs globally. In this context, determining the properties of LKS, such as *Anthocleista grandiflora* wood, could be a forerunner of substituting it for scarce, desirable, and high-value species [10]. Thus, for effective promotion and utilization of these LKS, it is imperative that their physical and mechanical properties, among other wood technological properties, be assessed to determine their commercial value and enhance their utilization [11]. CHEN *et al.* [1] explained that the physical and mechanical properties remain significant factors that influence the workability of wood. Dissimilarities in wood properties are natural due to their orthotropic nature. Also, these properties even differ in the same tree.

Density is relevant for applying wood in different industrial sectors [12–14]. Analyzing the density variation in the axial and radial direction of the species *A. colubrina*, *C. glandulosa*, *H. courbaril*, and *H. impetiginosus* native to the Brazilian semi-arid region, SANTOS *et al.* [12] found that in the radial direction, all species presented low-density values in the pith region, regardless of the height at which the samples were taken. This behavior was also observed for coniferous wood in studies by MELO [13] and ZAQUE *et al.* [14], with the highest values found in the trunk's peripheral area. For the axial direction, the highest values are in the base region.

Antocleista grandiflora is a species native to the African continent and distributed mainly in areas covering the countries of Cameroon, South Sudan, South Africa, and Comoros. This tree species is from the Gentianaceae family and grows well in humid tropical biome regions, reaching heights between 5 and 35 meters. The morphology of the leaves is sessile with petiolate characteristics for large trees; it also has a medium blade in dark green placement on the upper part and pale green on the lower part. When dry, the leaves have a color that varies between greenish and medium to dark brown [15]. According to MUDAU *et al.* [16], the dried or fresh roots and stems taken from *Antocleista grandiflora* are widely used in folk medicine to treat diseases such as diabetes mellitus. The retained wood *Antocleista grandiflora* can also be an alternative for industrial applications.

The development and efficient utilization of *A. Grandiflora* can help arrest present timber source difficulties and increase the base resource of wood. Utilizing this wood species will improve its technological properties and reduce the burden of inadequate traditional or native wood species [5]. In the context presented here, this paper aimed to evaluate the axial and radial variation of bonded wood's physical and mechanical properties (*A. grandiflora*) as an alternative wood resource base, thus improving the knowledge of timber to saw millers and other wood processing companies. Literary studies need more information about the technological properties of the African species *Anthocleista grandiflora*. Much of this is due to the difficulties in extracting these trees from the environment and the processing to make the samples. Therefore, the results of the physical and mechanical properties of *A. Grandiflora* are beneficial for future research focusing on using the species to replace others considered scarce.

2. MATERIAL AND METHODS

To carry out the research, trunks of the *Anthocleista grandiflora* Gilg were collected at ages 38, 43, and 47. Subsequently, clear, and defect-free samples were taken from each trunk's base, middle, and top regions, as indicated in Table 1. Before determining the physical-mechanical properties, the test specimens were conditioned at 20 ± 2 °C with a relative humidity of 65 ± 2%. All tests were carried out following the British Standard – BS 373:1957 [17].

Table 1: Description of test specimens of *Anthocleista grandiflora* Gilg for physical and mechanical tests.

TESTS CONDUCTED	PROPERTIES EVALUATED	SPECIMENS' GEOMETRY (mm)	QUANTITY OF SPECIMENS
Physical properties	Moisture content	20 × 20 × 20	180
	Density		
	Water absorption		
	Volumetric swelling		
	Volumetric shrinkage		
Mechanical properties	Static bending	20 × 20 × 300	180
	Compression strength	20 × 20 × 60	
	Shear strength	50 × 50 × 50	
	Hardness	50 × 50 × 150	

2.1. Physical properties

2.1.1. Moisture content (MC)

A. grandiflora wood samples with a dimension of 20 mm^3 were extracted from all the sections (base, middle and top) of the three tree trunks (Figure 1A). The specimens were accurately weighed towards a margin of 0.001g and desiccated to continual temperature in oven at 103 ± 2 °C for 24 h. The desiccating stopped when the dissimilarity amongst weights of two successive did not surpass 0.002 g. The weight of oven-dried specimens was recorded, and the percentage MC was determined.

2.1.2. Density

To determine the density, we first weighed the samples at 0.001g accuracy on an electronic scale, KERN PCB 1000-2 (WD160072162). Measured dimensions of rectangular specimens were with 0.001 mm accuracy with digital caliper (Figure 1B). The volume was calculated by multiplying the three dimensions of the rectangular specimens; the wood density (12%) (ρ) was evaluated and expressed as g cm^{-3}.

2.1.3. Other physical properties

Water absorption, volumetric swelling, and shrinkage were evaluated using 20 mm^3 specimens. The four-sided specimen sizes were measured at 0.001 mm volume accuracy, then computed by weighing specimens to obtain the initial weight, and then submerged horizontally under 25 mm depth of clean water at a temperature 26 ºC for 72 h (Figure 1C). The specimens were removed and placed in a conditioning chamber until they attained mandatory (12%) moisture content. The equations provided by the standard determined the properties of water absorption, volumetric swelling, and shrinkage.

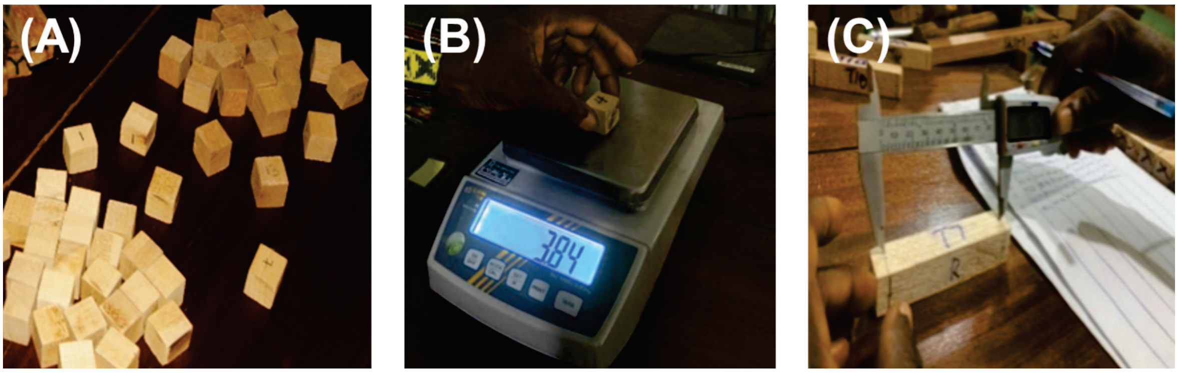

Figure 1: Determination of the physical properties of *A. grandiflora* wood. (A) Samples are used in density test. (B) Weighing the sample to determine the moisture content. (C) Measuring dimensional stability.

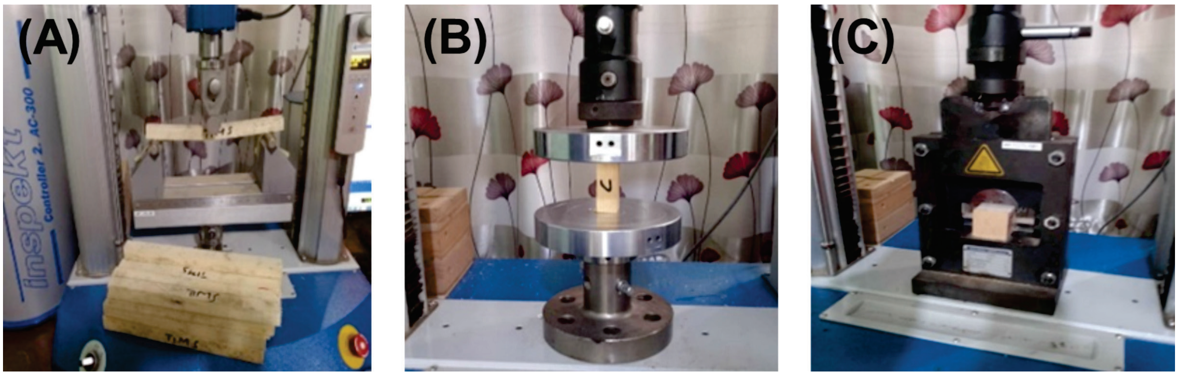

Figure 2: Sequence of procedures to determine mechanical properties of *A. grandiflora* wood. (A) Static bending. (B) Compression strength. (C) Shear strength.

2.2. Mechanical properties

Static bending, parallel-to-grain compression strength, parallel-to-grain shear strength, and Janka hardness were determined (Figure 2A, B, and C) following the procedures from the British Standard – BS 373:1957 [17]. All tests were performed using a universal machine test (UTM), model 4482, equipped with a 50 kN load cell. Three-point flexural strength tests were performed at a 6.5 mm min^{-1} speed. Parallel compression resistance tests were carried out at a 0.6 mm min^{-1} speed and stopped all tests after all samples were broken. For Janka hardness determination, a 100 kN load cell was employed with a depth gauge attached to the UTM.

3. RESULTS AND DISCUSSION

3.1. Physical properties

Moisture content (MC) has been appreciated as one of the properties of wood species that decreases mechanical strength properties; thus, it needs to be controlled to an acceptable level for the appropriate utilization of the species in the construction and furniture industry. In the cross-section (radial), the MC usually increases from the heartwood to the sapwood. In 38-year-old trees, the MC (Table 2) was measured at 12.2% in the heartwood and 13.4% in the sapwood. A similar trend was also observed in 43-year-old trees, as the heartwood and sapwood recorded MC of 12.68 and 13.1%, respectively. Meanwhile, 43-year-old trees recorded 13.6% and 14.5% for the heartwood and the sapwood, respectively. In the axial direction of these trees, the MC increases from the base to the top, as indicated in Table 2. The results suggest no difference in the MC in the heartwood and the sapwood of trees for all ages. The moisture content in *A. grandiflora* is high at the top compared to the other sections. Similar results were reported by NURFAIZAH *et al.* [18] and SHUPE *et al.* [19].

The density of 38-year-old trees ranged from 371.2–354.7 and 421.9–382.3 kg m^{-3} in the heartwood and the sapwood, respectively, from the base to the top (Table 2), 43-year-old trees recorded 400.1-378.7 and 429.4–398.9 kg m^{-3} in the axial direction. At the same time, that of 47-year-old trees was 434.3–401.5 and 477.3–419.9 kg m^{-3}. This influence of age on density was also observed by MELO [13].

The density reduces from the base to the top in studied trees for axial and radial directions. This is a general trend since wood density is usually higher at the base due to the higher compaction of the stump tissues exerted by overlapping cells along the trunk and tree crown [12–14, 20]. AYARKWA [21] and NIEMZ and SONDEREGGER [22] emphasized that the samples extracted from the top part of the tree have lower density and strength properties in most tree species. The density of *A. grandiflora* is comparable to that of *Alstonia boonei* and *Hannoa klaineana* and are classified as low density according to the Timber Industry Development Division (TIDD) wood density classification, and thus could be used in the light construction industry and the production of particleboard, molding, cabinet, and handicraft. The intra-tree strength property variation could result from density variation, as ZOBEL and VAN BUIJTENEN [23] observed, that wood density strongly correlates with the strength properties of wood, yield, and general quality of most wood products.

The *Anthocleista grandiflora* water interaction characterization is exhibited in Table 2. The results show that along the trunk, from the base to the top water absorption (WA) of *A. grandiflora* ranged from 140.8–160.9%, 131.1–150.3%, 131.3–149.1% for heartwood for trees of 38-, 43-, and 47-year-old respectively, whereas their sapwoods recorded 178.5–181.4%, 151.0–162.5% and 165.5–174.6. It was observed that water absorption

Table 2: Physical properties at the trunks' base, middle, and top section from 38-year-old, 43-year-old, and 47-year-old *Anthocleista grandiflora* trees.

SECTION	PARAMETER MEASURED	38-YEAR-OLD		43-YEAR-OLD		47-YEAR-OLD	
		HEARTWOOD	SAPWOOD	HEARTWOOD	SAPWOOD	HEARTWOOD	SAPWOOD
Base	Moisture content (%)	12.2 (0.20)	13.4 (0.15)	12.7 (0.01)	13.1 (0.04)	12.8 (0.11)	13.4 (0.23)
	Density (kg m^{-3})	371.2 (40.9)	421.9 (23.4)	400.1 (14.0)	429.4 (12.3)	434.3 (30.1)	477.3 (18.9)
	Water absorption (%)	140.8 (12.7)	178.5 (10.7)	131.1 (6.8)	151.0 (10.9)	131.3 (7.6)	165.5 (15.2)
	Volumetric swelling (%)	41.8 (0.9)	43.8 (0.7)	37.6 (1.4)	38.3 (0.7)	39.1 (1.0)	36.1 (1.1)
	Volumetric shrinkage (%)	33.5 (2.0)	36.3 (1.6)	29.8 (1.9)	40.9 (1.6)	32.3 (1.9)	38.9 (1.4)
Middle	Moisture content	13.4 (0.10)	14.2 (0.03)	12.9 (0.40)	13.1 (0.09)	13.4 (0.35)	14.3 (0.16)
	Density (kg m^{-3})	358.7 (13.2)	387.6 (11.1)	397.8 (17.4)	398.9 (15.3)	411.1 (27.1)	425.7 (14.9)
	Water absorption (%)	158.8 (10.2)	180.0 (6.1)	154.3 (11.4)	153.4 (6.1)	148.1 (7.9)	171.8 (9.9)
	Volumetric swelling (%)	44.4 (1.4)	47.3 (1.5)	41.5 (1.1)	47.6 (1.5)	42.9 (0.6)	51.6 (0.6)
	Volumetric shrinkage (%)	36.9 (1.9)	40.6 (2.1)	35.1 (2.3)	41.2 (2.1)	35.7 (2.0)	47.6 (1.5)
Top	Moisture content	14.3 (0.05)	14.6 (0.03)	13.2 (0.07)	13.2 (0.18)	14.6 (1.15)	15.9 (2.37)
	Density (kg m^{-3})	354.6 (18.3)	382.3 (10.2)	378.7 (8.8)	395.1 (10.5)	401.5 (21.0)	420.0 (26.8)
	Water absorption (%)	161.0 (21.2)	181.4 (7.0)	150.3 (2.3)	162.5 (7.0)	149.1 (13.2)	174.6 (14.7)
	Volumetric swelling (%)	47.5 (0.5)	55.9 (1.2)	45.1 (0.9)	51.5 (1.2)	48.2 (1.0)	50.8 (1.2)
	Volumetric shrinkage (%)	41.5 (1.4)	43.1 (1.8)	38.7 (1.7)	42.7 (1.5)	43.1 (1.5)	40.4 (1.1)

Standard deviation in parenthesis.

reduces from the base to the top in the heartwood and increases from the base to the top in the sapwood. Similar results were obtained by LASKOWSKA *et al.* [24] and SANDBERG [25]. Although the water absorption was found to be smaller in the heartwood, it could also be observed to be more porous.

For the sapwood specimens, the moisture content was higher further into the samples than for the heartwood specimens, in agreement with previous studies by FREDRIKSSON and LINDGREN [26] on water absorption of Norway spruce heartwood and sapwood. In the axial position, the water absorption was higher at the top than the base and decreased from sapwood to heartwood. This pattern is evident in 38-, 43-, and 47-year-olds. Again, in the radial position, the sapwood of 38-year-olds (179.9%) recorded the highest value of WA. Generally, the sapwood in all the radial positions had the highest WA values in conformity with previous studies [27, 28]. The axial positions of trees of all ages differed in the WA pattern, like recorded WA values in the radial sections. A similar observation was made by ADEBAWO *et al.* [28].

Anthocleista grandiflora recorded high volumetric swelling (VSW) along the top section in the axial direction and the sapwood in the radial direction in all the trees. The axial VSW in 38-year-old trees varies between 41.8–43.8, 44.4–47.3, and 47.5–55.9%. The 43-year-old trees recorded VSW values ranging from 37.6–38.3, 41.5–47.6, and 45.1–51.5%, whereas 47-year-old trees recorded 39.1–36.1, 42.9–51.6, and 48.2–50.8% for the base, middle, and the top respectively as shown in Table 2. It could be observed that the heartwood swells more than the sapwood in the base, whereas, in the middle and top, the sapwood swells more than the heartwood in the axial direction. Similar results were obtained by CARDOSO and PEREIRA [29]. The development of the study confirms that there was a higher VSW at the top of all the specimens compared to the base. The volumetric shrinkage of 38-year-old along the axial positions (base-top) ranged from 36.27–33.5%, 40.6–36.9% and 43.1–41.5%, 43-year-old recorded 40.9–29.8%, 41.2–36.9% and 42.7–41.5% in the exact directions, whereas 47-year-old obtained 32.3–38.9%, 35.7–47.6% and 43.1–40.4%. It was observed in the study that the sapwood shrinks more than the heartwood in the three trees. It is expedient to note that shrinkage in *A. grandiflora* decreases from the top to the base, as indicated in the results.

3.2. Mechanical properties

Table 3 shows the result of modulus of elasticity - MOE along the axial and radial positions of all trees of *A. grandiflora* species evaluated. The mean values of MOE obtained from the 38-year-old along the axial position from the base to the top were 6377.3–5445.3 MPa, the 43-year-old recorded 6632.1-5605.1 MPa, whereas the 47-year-old obtained 6993.0–6185.4 MPa. The results indicate that heartwood recorded higher MoE values than their respective sapwood in the different sections. The heartwood of 47-year-old trees from the base recorded the highest MoE (6993.0 MPa), whereas the sapwood from the top section of 43-year-old ones recorded the lowest

MoE (5445.3 MPa). Hence, in all the trees, MoE is higher in the base and the heartwood than in the sapwood. Similar results were obtained by BRUNETTI *et al.* [30], CAVALLI *et al.* [31] and GALLEGO *et al.* [32].

The average modulus of rupture - MOR values recorded for 38-, 43-, and 47-year-olds of *A. grandiflora* range from 47.1-28.3 MPa, 52.2-32.4 MPa, and 63.3-39.7 in the axial and radial positions. Table 3 indicates that the base of 47-year-olds recorded the highest MoR compared to 38- and 43-year-olds. This can result from the cambium's age, the tree morphology, and internal changes through genetic differences or controls [33]. This trend is seen in older trees' axial and radial positions. Similar results were obtained by BRUNETTI *et al.* [30], CAVALLI *et al.* [31] and GALLEGO *et al*. [32].

The variation in static bending strength properties in the axial and radial directions could also be due to factors such as growth and silvicultural practices, conditions, high phytochemical compounds, and inherent variability within the tress, as observed by CHOONGE *et al.* [34]. Hence, it is imperative to appreciate that *A. grandiflora*, for all ages, generally have the highest static bending strength at the base and in the heartwood. Similar characteristics were recorded for Scot pine (*Pinus sylvestris*), Turkish red pine (*Pinus brutia*), Asian poplar wood (*Populus usbekistanica* "Afganica"), and eucalyptus (*Eucalyptus grandis*) [34]; *Fagus orientalis* and *Fagus sylvatica* species [35]; *Picea abies*, *Larix decidua*, *Quercus robur* L., *Fraxinus excelsior* L., *Fagus sylvatica* L., *Tilia cordata* Mill, *Betula pendula* Roth [36].

The results of the parallel-to-grain compression strength indicated that the means of *A. grandiflora* specimens 38-, 43-, and 47-year-olds were 24.3, 27.9, and 31.0 MPa, with standard deviations of 1.5, 1.3, and 0.9, respectively. It was observed that the heartwood in the base section of a 47-year-old (41.3 MPa) recorded the highest compressive strength, followed by that of a 43-year-old (35.9 MPa). Analysis of the results for the three trees in the axial and radial directions showed a variation in resistance values (Table 3). The variation between the three trees could be attributed to the chemical composition of the wood species, which could impact the strength [37]. High strength in compression parallel to the grain is required of timber used as columns, posts, and notched timbers, as seen in *Memecylon lateriflorum* (62.4 MPa) OHEMENG *et al.* [10], another LKS/LUS. However, that of *A. grandiflora* (27.8 MPa) falls in the same range as *Aningeria robusta* wood (27.2 MPa) [38]. Lower parallel-to-grain compression strength could suit furniture and other fitments.

The resistance values observed for the species under study were intermediate, allowing it a wide range of uses, including using its wood for structural uses. STANGERLIN *et al.* [11], evaluating the resistance to parallel compression of wood from ten LKS species from the Brazilian Amazon region, observed values varying between 37 and 86 MPa. MELO *et al*. [39] evaluated wood properties from 30 forest species, verifying values between 22 and 59 MPa, with average values around 40 MPa.

The shear strength parallel to the grain is an important property that comes into play in the structural use of timber in jointing [40, 41]. The mean values of shear strength parallel to the grain of *A. grandiflora* 38-, 43-, and 47-year-olds were 6.6, 7.1, and 8.2 MPa, respectively. Where the base of older trees recorded the highest shear strength value (11.2 MPa), the 43-year-old recorded 9.6 MPa, and the 38-year-old recorded 8.4 MPa, as shown in Table 3.

Within the tree height, there were variations from the base sections to the top sections. The base sections recorded the highest values, followed by the middle and top sections. There were slight but significant variations in the shear strength of the heartwood and sapwood in the middle and top sections of *A. grandiflora* (Table 3). CARREIRA [42] submitted that these variations may result from the number of growth rings present in the wood species, which influences determining the strength properties of wood. Similar results were obtained by ADEBAWO *et al.* [28].

Hardness is an essential parameter for wood quality [43], since the hardness of wood has a good relationship with various mechanical properties. Hence, the resistance to indentation characteristics of *A. grandiflora* was evaluated in the radial and tangential directions. The test results indicated that the mean radial hardness in 38-, 43-, and 47-year-olds were 1.4, 1.4, 1.3, 1.5, and 1.8 and 1.7 MPa for the axial and radial directions, respectively. The tangential hardness recorded for 38-, 43-, and 47-year-olds were 1.6, 1.2, 2.1, 1.5, 3.1, and 2.3 MPa in the axial and radial directions, respectively, as shown in Table 3.

Higher mean hardness was observed at the base sections of the heartwood of the 38-, 43-, and 47-year-olds. Hence, the radial and tangential hardness properties of *A. grandiflora* increased from the top to the base. These study results relate well with the work of SYDOR *et al.* [44], who emphasized that the higher the wood density, the higher the hardness value. These results have also been confirmed by HOLMBERG and SANDBERG [45], who reported that the hardness of wood is higher in the axial direction than sidewise, and radial surfaces usually have higher hardness than tangential surfaces. Further research is being conducted on this species' durability properties to evaluate its response to termite and fungi attacks and enhance its utilization in the timber industry.

Table 3: Mechanical properties of the trees' base, middle, and top section with 38-year-old, 43-year-old, and 47-year-old *Anthocleista grandiflora* wood.

PARAMETER	SECTION	38-YEAR-OLD		43-YEAR-OLD		47-YEAR-OLD	
		HEARTWOOD	SAPWOOD	HEARTWOOD	SAPWOOD	HEARTWOOD	SAPWOOD
MOE (MPa)	Base	6377 (318)	6632 (329)	6993 (198)	6265 (366)	6271 (194)	6778 (156)
	Middle	5906 (294)	6071 (221)	6701 (161)	5818 (347)	6044 (242)	6511 (180)
	Top	5854 (318)	5932 (374)	6421 (139)	5445 (396)	5605 (323)	6185 (148)
MOR (MPa)	Base	47 (1.8)	62 (1.1)	63 (0.9)	35 (1.7)	43 (2.3)	48 (0.8)
	Middle	37 (1.7)	47 (2.1)	54 (1.0)	34 (2.1)	39 (2.6)	43 (0.6)
	Top	34 (1.4)	40 (1.8)	45 (1.0)	28 (1.2)	32 (1.8)	39 (0.4)
Co (MPa)	Base	29 (1.8)	36 (1.4)	41 (0.8)	24 (1.8)	27 (1.4)	33 (1.3)
	Middle	26 (0.9)	30 (1.1)	32 (0.3)	22 (1.7)	25 (1.4)	27 (0.4)
	Top	25 (1.1)	27 (1.3)	28 (1.3)	20 (1.8)	23 (1.1)	25 (1.1)
Sh (MPa)	Base	8.4 (0.4)	9.6 (0.4)	11.2 (0.4)	6.5 (0.2)	6.6 (0.4)	7.4 (0.4)
	Middle	6.6 (0.3)	7.3 (0.3)	9.0 (0.3)	6.0 (0.3)	6.5 (0.4)	7.0 (0.3)
	Top	6.4 (0.2)	6.9 (0.2)	7.9 (0.2)	5.6 (0.3)	5.9 (0.1)	6.9 (0.2)
Hr (MPa)	Base	1.52 (0.23)	1.68 (0.12)	1.83 (0.33)	1.48 (0.12)	1.53 (0.12)	1.69 (0.10)
	Middle	1.47 (0.07)	1.65 (0.27)	1.79 (0.41)	1.35 (0.08)	1.48 (0.07)	1.69 (0.11)
	Top	1.17 (0.21)	1.44 (0.23)	1.62 (0.25)	1.26 (0.15)	1.33 (0.12)	1.59 (0.24)
Ht (MPa)	Base	2.04 (0.15)	2.53 (0.21)	3.21 (3.22)	1.39 (0.23)	1.91 (0.14)	2.68 (0.19)
	Middle	1.44 (0.11)	1.97 (0.17)	3.09 (0.22)	1.07 (0.15)	1.74 (0.06)	2.37 (0.16)
	Top	1.27 (0.22)	1.64 (0.01)	2.88 (0.14)	1.04 (0.12)	0.94 (0.12)	1.98 (0.16)

MoE: modulus of elasticity, MoR: modulus of rupture, Co: Compression strength, Sh: Shear strength, Hr: Radial hardness, Ht: Tangential hardness.

4. CONCLUSIONS

The study found that, although there are variations in the physical and mechanical properties in the axial and radial directions of *Anthocleista grandiflora* wood, these variations meet the benchmark for the industrial utilization of the species for construction, furniture, and other artifacts. This considerable variation in this species does not distinguish it from congeners and negatively affects its relevance in the timber industry. However, the revealed characteristic has enhanced the competitiveness of the species to the premium ones that are endangered, vulnerable, or are getting extinct and exhibited the suitability of substituting them for use.

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