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VARIATIONS IN THE DIMENSIONAL STABILITY OF *Aningeria robusta* A. Chev. WOOD

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ABSTRACT

Dimensional changes in wood influences its effectiveness as a construction material and is largely due to variation in moisture content of wood and its immediate environment. Hence, this study investigated variations in dimensional stability of the wood of *Aningeria robusta* to determine its functionality in service and hence its suitability in the wood industry. Six trees of *A. robusta* were harvested from Gambari Forest Reserve, south-west Nigeria for this study. Wood samples were collected from the outer, middle and inner sections of the radial direction and also axially at the base (50 cm above the ground), 10, 30, 50, 70 and 90% of the merchantable height. Test specimens of 20mm x 20mm x 40mm were properly aligned and denoted Tangential and Radial planes. They were soaked in water for 72 hrs in order to get them conditioned to moisture above Fibre Saturation Point. Specimens were removed, dimensions taken in wet conditions using a vernier calliper. They were oven-dried at 103^{o}C and percentage shrinkages were measured. Mean radial shrinkage was 1.10% with an inconsistent axial variation and a decreasing trend radially. Tangential shrinkage had a mean value of 1.35% with an inconsistent pattern of variation both axially and radially. Volumetric shrinkage was 2.41%; it increased gradually along the axial direction but inconsistently in the radial plane. The lower value of the radial shrinkage compare with the tangential shrinkage is in conformity with documented research findings on economic hard wood species. Variations in both axial and radial axes were statistically insignificant (p=0.05) for the three directions evaluated. The values obtained for the tangential (1.35%) and radial (1.10%) shrinkages of *A. robusta* were within the ranges specified for general utility, its small movement in service also make it readily useful for general utility which cuts across general wood utilisation. In conclusion, *A. robusta* can be used for general utility especially in door and window frames, solid doors and windows, roofing, furniture and joinery. The variations have implications on dimensional stability of the species and therefore on the utilisation potentials.

Keywords: Dimensional stability, Radial, shrinkage, Tangential, Volumetric, fibre saturation

Introduction

Wood is both hygroscopic and anisotropic in nature, hence, when it loses moisture below fibre saturation point (FSP) it shrinks, and swells when water is absorbed from the immediate surroundings. The percentage change in wood dimension as a result of moisture loss is termed shrinkage (Dinwoodie, 1989). Shrinkage is the change in volume of timber from green condition to its condition when dried to a specific moisture content of usually 12% (Steve, 2014). The observed changes in wood dimension as a result of shrinkage are unequal along the three structural directions viz: tangential, radial and longitudinal because of its anisotropic nature (Amtzen and Charles, 1994). According to Panshin and deZeeuw (1980) and Amtzen and Charles (1994), the geometric disposition of cells, orientation of the wood fibres and the manner in which a tree increased in diameter as it grows along the principal directions are mainly responsible for this. The magnitude of shrinkage and swelling depends on the amount of moisture either gained or lost by wood during fluctuation of moisture content (Ogunjobi *et al*., 2018). The greatest dimensional shrinkage occur along the tangential plane, shrinkage along the radial plane is considered less while the longitudinal shrinkage has been widely reported to be the least (Desch,1988 and Dinwoodie, 1989). The greater the amount of cell materials present, the larger the dimensional changes. Suitability of wood for certain end uses has been linked with Tangential/Radial shrinkage ratio which Panshin and deZeeuw (1980) reported that high suitability of wood for end uses is synonymous with low T/R ratio. Dimensional stability affects how a final wood product will move and distort in service and consequently is an important wood property to understand noted (Sargent, 2019).

Drying wood products to the moisture content best suited for intended use will eliminate most related problems and also ensure retention of its dimensional stability (Steve, 2014). Also It should be noted that proper drying of wood before use will reduce drying defects, increase strength, minimize dimensional changes and also provides a better base for paints, finishes, preservatives and adhesives of the concerned wood (Helmuth, 1990 and Ogunjobi *et al*., 2018).

FAO (1976) noted that resources of commercial woods are dwindling. FAO and UNEP (2020) noted that forest and the biodiversity they contain continue to be under threat from actions to convert the land to agriculture or unsustainable levels of exploitation, much of which is illegal hence, increasing efforts are needed to introduce lesser-used wood species. Also, Eddowes (1980), in discussing the technical aspects of promoting lesser-known tropical species (LKTS) in tropics identified inadequate data on physical properties (dimensional stability inclusive) as one of the problems. However, *Aningeria robusta*, a LKTS is a hardwood native to West Africa. This species is gaining popularity in the timber market in the last few decades. However, an essential prerequisite for promotional action is the provision of basic knowledge on the quality of lesser-used species.. *Aningeria robusta*, a lesser-used timber species is a hardwood native to West Africa but its marketability of the species depends on what is available to show in terms of properties that are inherent in the species for users to exploit. It is believed that exploring the species will not only reduce pressure on the popular and scarce species, but also help in the efficient management of the ecosystem. This study therefore investigated the axial and radial variations in the dimensional stability of *A robusta*.

Materials and Method

Six trees of *A. robusta* were harvested from Gambari Forest Reserve, south-west Nigeria. The Reserve lies between latitude 7° 25' N and longitude 3° 53' E. The trees were converted to six bolts of 50 cm long collected at the base (50 cm above the ground), 10, 30, 50. 70, and 90% of the merchantable height. The bolts were partitioned into three equal zones viz: innerwood, middlewood and outerwood along the radial plane in accordance with the procedure of Onilude and Ogunsanwo (2002). Each zone was replicated twice, 36 test samples were collected per tree making a total of 216 test samples for the 6 trees. 10, 30, 50, 70 and 90% of the merchantable height. The bolts were partitioned into three equal zones; inner wood, middle wood and outer wood along the radial plane as in Onilude and Ogunsanwo (2002). A total of 216 test samples of dimensions 20 × 20 × 40 mm were collected from each tree to give a total of 1080 test samples.

The conversion was done in the Wood Workshop of Wood and Paper Technology Department, Federal College of Forestry, Ibadan in accordance with the British Standard, BS 373 method of testing small clear specimen of timber. They were kept in a dessicator and left under ambient room temperature for one month in the Wood Science Laboratory before testing in order to prevent possible dimensional changes as a result of loss of moisture from wood.

Test specimens of 20mm x 20mm x 40mm were prepared for this test; they were properly aligned and denoted 'T' and 'R' for Tangential and Radial planes respectively. They were soaked in water for 72 hours in order to get them conditioned to moisture above Fibre Saturation Point (FSP). Specimens were removed one after the other; their dimensions in wet condition were taken and recorded to the nearest millimetre using a vernier calliper. Percentage shrinkages along the two planes were measured after specimens had been oven-dried at 103°C as:

$$S = \frac{DS-DO}{DO} \times 100 \text{.........................(1)}$$

Where S= Shrinkage %
DS= dimension of saturated condition
DO= dimension of oven-dried condition

$$SR + ST = VS \text{.......................... (2)}$$

Where VS= Volumetric shrinkage
SR= Radial shrinkage
ST= Tangential shrinkage

This is in accordance with approximations done by Dinwoodie, (1989).

Split-plot experimental design was adopted used , hence, data obtained were analysed using descriptive statistics and analysis of variance (ANOVA).

Results and Discussion

The results obtained from radial shrinkage (RS) test are presented in Table 1. while the ANOVA is shown in Table 2. The mean value of RS was 1.10% ranging from 0.90% to 1.34% along the sampling height. It increased from 0.90% at the base to 1.34% at 30% of the merchantable height where it decreased till 90% of the height. Meanwhile, Chudnoff (1980) had earlier reported a mean value of 3.8% while PROTA (2010) recorded a range of 3.9 to 4.1% on the same species. Poku *et al.* (2001) obtained a mean value of 2.51% for *Alstonia boonei*, 4.01% for *Petersianthus macrocarpus* and 2.23% for *Ricinodendron heudelotti* being lesser-known hardwood species from Ghana, while Ogunjobi *et al.* (2018) obtained a mean value of 3.25% on plantation grown *Tectona grandis*. The large variance could have been attributed to the effect of geographical location, sampling intensity and age of trees sampled. Moreover, it happens when more latewood is formed than earlywood (Chudnoff, 1980). Generally, an inconsistent pattern of variation was observed along the sampling height (Table 1).

A general increase in radial value with increasing height was reported by Poku *et al. (*2001) in their work on *Petersianthus macrocarpus*, a lesser-used species from Ghana. Ogunsanwo (2000) observed an inconsistent pattern along the length of *Triplochiton scleroxylon*. Ogunjobi *et al.*(2018) noted an increase from the base towards the middle. All are at variance with the findings of Young *et al.* (1991) who reported a decreasing trend with increasing height. The reason could be traced to the masking effect of heartwood extractive content, which limits the predictability of wood shrinkage from cell wall thickness. It could also be the influence of the microfibril angle of S2 layer which plays a critical role in influencing shrinkage (Ogunjobi *et al.*2018).Across the stem, radial shrinkage decreased gradually from the innerwood to outerwood (Table 1), though a reversal of the trend was observed by Ogunjobi*et al.* (2018) on *Tectona grandis* and Ogunsanwo (2000) in his work on Obeche. Bendsten and Sneft (1986) observed a significant non-uniform changes from pith outwards which tend to be more or less stable towards the outer rings. This may be linked with the extent of cellwall development as dictated by age. Statistically, none of the sources of variance were significant at 5% probabilitylevel (Table 2).

Table 1: Mean Values of Radial Shrinkage of *Aningeria robusta* along and across the bole

Wood Type	Sampling Height (%)						
	Base	**10**	**30**	**50**	**70**	**90**	**Mean**
Innerwood	0.94±0.01	1.09±0.006	2.04±0.03	0.94±0.01	1.10±0.01	0.97±0.02	1.18±0.06
Middlewood	0.8±0.01	1.24±0.005	1.01±0.02	1.33±0.15	1.02±0.02	1.16±0.04	1.10±0.10
Outerwood	0.90±0.02	1.02±0.02	0.98±0.03	1.14±0.05	1.06±0.07	1.05±0.05	1.03±0.03
Mean	**0.90±0.03**	**1.12±0.03**	**1.34±0.14**	**1.14±0.07**	**1.06±0.43**	**1.06±0.43**	**1.10±0.017**

Table 2: Results of Analysis of Variance (ANOVA) for Dimensional Stability of *Aningeriarobusta.*

Source of variation	df	Radial	Tangential	Volumetric
Tree (Blocks)	5	2.67*	1.50ns	1.5ns
Sampling Height (SH)	5	2.16ns	0.31ns	0.19ns
Major Plot Error	25			
Radial Position (RP)	2	0.41ns	3.25*	3.18*
Interaction (SH*RP)	10	0.41ns	0.29ns	0.27ns
Sub Plot Error	50			
Total	97			

Ns-not significant (P>0.05); *-significant (P=0.05)

The mean tangential shrinkage (TS) was 1.35%; ranging from 0.89 to 3.42% (Table 3). Chudnoff (1980) recorded a mean value of 7.0% for *Aningenia robusta* while PROTA (2010) recorded a range of 6.7 to 7.6% for the same species. Poku *et al.* (2001) reported a mean value of 4.4%, 6.8% and 4.0% for *Alstonia boonei*, *Petersianthus macrocarpus* and *Ricinodendron heudelotti* respectively being lesser-used hardwood species from Ghana. Ogunjobi *et al.* (2018) reported a mean value of 3.01% on *Tectona grandis* from Nigeria. Tangential shrinkage had significant effect on dimensional stability at 5% probability level (Table 2). Variations in the values reported could have been accounted for by size and shape of the piece which affects the grain orientation in the piece and the uniformity of the moisture through the thickness (Haygreen and Bowyer, 1989). Other factors that could have led to the variation include density of the sample, geographical location, age of trees and the sampled species. An inconsistent pattern of variation was observed both along and across the tree stem (Table 3). Similar trend was observed in *Alstonia boonei, Triplochiton scleroxylon* and *Tectona grandis* by Poku *et al.*(2001), Ogunsanwo (2000) and Ogunjobi *et al.* (2018) respectively. However, it was at variance with what Poku*et al.* (2001) observed in *Peterslanthusmacrocarpus* and *Ricinodendron heudelotti* from Ghana. They observed that the values increased from the base to the middle and decreased sharply abruptly to the top whereas Young *et al.* (1991) reported a decreasing trend with increasing height. This may be linked with the extent of cell wall development as dictated by the age of the sampled tree. Panshin and deZeeuw (1980) reported that it could have been caused by the thickness of cellwall which they opined controls to a large extent the shrinkage behaviour in woods. Radial shrinkage (1.10%) was observed to be lower than the tangential shrinkage (1.35%), this is in consonant with the findings of Ying *et al.*, (1994) Choong *et al* (1989), Lausberg *et al.* (1995), Ogunsanwo (2000) and Poku *et al.* (2001) and it is believed to be caused by the presence of ray cells on the radial plane with their horizontally aligned cells producing a restraining effect on radial shrinkage noted Lausberg *et al.* (1995). However, Panshin and deZeeuw (1980) noted that it is related to the rapid reduction of the microfibrillar angle in the cellwall. Ogunjobi *et al.* (2018) reported a decreasing trend from the innerwood outwardly which was contrary to the findings of this study. The values reported for the tangential (1.35%) and radial (1.10%) shrinkages were in conformity with the assertion of Okigbo (1965) that species in these ranges of shrinkages could be used for general utility since they have small movement in service (Table 5). Ajala (2006) also discovered that *A. robusta* was used for general utility especially in door and window frames, solid doors and windows, roofing, furniture and joinery.

Table 3: Mean values of Tangential Shrinkage of *Aningeria robusta* along and across the bole

Wood Type	Sampling Height (%)						
	Base	10	30	50	70	90	Mean
Innerwood	0.94±0.34	0.89±0.06	1.02±0.02	0.86±0.05	1.01±0.25	4.55±0.65	1.55±0.31
Middlewood	0.94±0.05	1.05±0.13	1.02±0.23	0.90±0.10	1.02±0.17	1.14±0.12	1.01±0.12
Outerwood	0.78±0.07	0.95±0.05	1.01±0.03	0.98±0.20	1.63±0.38	4.47±0.64	1.49±0.30
Mean	**0.89±0.11**	**0.96±0.04**	**1.02±0.04**	**0.91±0.16**	**0.89±0.27**	**3.24±2.07**	**1.35±0.41**

The results obtained for volumetric shrinkage (VS) test are presented in Table 4. the ANOVA is presented Table 2 while Volumetric shrinkage had significant effect on dimensional stability at 5% probability level (Table 2). The mean value was 2.41%, ranging from 1.77% at the base to 4.49% at 90% of the merchantable height. Chudnoff (1980) recorded a mean value of 11.8% on the same species. Poku *et al.* (2001) also recorded 7.51%, 11.51% and 6.21% for *A. boonei*, *P. macrocarpus and R. heudelotti* respectively. Meanwhile, Ogunjobi *et al.* (2018) reported 9.82% in *Tectona grandis*. Volumetric shrinkage and swelling properties are affected by several wood factors, such as the heartwood to sapwood ratio of the fibrillary angle on the S2 layer. Hence, the wide disparity noticed in all these hardwood species could have been attributed to age of trees, geographical location and probably presence of more biomass in latewood cells noted Chudnoff (1980). Volumetric shrinkage increased from the base to the middle of trunk and then decreased gently towards the apex. Similar trend was reported in the work of Poku *et al.* (2001) and Ogunjobi *et al.* (2018) on *A. boonei* and *Tectona grandis* respectively. However, Poku *et al.* (2001) and Rigatto, (2004) reported different trend in *P. Microcarpus*, *R. heudeloti* and pine timber respectively. The variation in these results may be due to the presence of greater amount of extractives in the inner wood which tend to inhibit normal shrinkage by bulking the amorphous regions in the cell wall substances. Radially, the trend was not consistent; it decreased to the middlewood and then increased towards the bark. In a similar work on *Tectona grandis*, Ogunjobi *et al.* (2018) reported an increase in VS from the innerwood towards the back. This might be due to the masking effect of extractive content. Panshin and dezeeuw (1980) noted that it is related to the rapid reduction of the microfibrillar angle in the cellwall and the cellulose content. Statistically, there was no significant difference in the effect of volumetric shrinkage (Table 2)

Table 4: Mean Values of Volumetric Shrinkage of *Aningeria robusta* along and across the bole

Wood Type	Sampling Height (%)						
	Base	10	30	50	70	90	Mean
Innerwood	1.81±0.54	2.01±0.84	2.13±0.98	1.82±0.55	2.12±0.97	5.53±3.75	2.57±0.08
Middlewood	1.81±0.563	2.34±0.73	2.04±0.73	2.23±1.07	2.04±0.73	2.04±0.73	2.13±0.98
Outerwood	1.69±0.42	1.97±0.69	2.00±0.70	2.17±1.01	1.69±0.43	5.63±0.43	2.53±0.06
Mean	**1.77±0.50**	**2.11±0.96**	**2.06±0.74**	**2.07±0.75**	**1.95±0.91**	**4.49±0.68**	**2.41±0.79**

Table 5: Shrinkage values of *Aningeria robusta* in comparism with those of other species

Species	Tangential Shrinkage (%)	Radial Shrinkage (%)	Movement
Terminalia superba	1.3	1.0	S
Alstonia boonei	1.3	0.9	S
Distemonanthus benthamianus	1.3	0.8	S
Terminalia ivorensis	0.78	0.5	S
Erythrophloeum spp.	1.2	1.0	S
Entandrophragma angolense	1.6	1.2	S
Triplochiton scleroxylon	1.25	0.8	S
Milicia excelsa	1.0	0.5	S
**Aningeria robusta*	1.35	1.10	S

S-Small Movement
Source- Okigbo (1965)
*Current Study

Conclusion and Recommendation

Though, an inconsistent variation was observed in most of the properties investigated and no significant difference (at 5% probability level) was observed in all the sources of variation studied in *Aningeria robusta*, yet the values of tangential (1.35%) and radial (1.10%) shrinkages compares relatively well with the likes of *Alstonia boonei*, *Terminalia species*, *Triplochiton scleroxylon* which have small movement in service and could be used for general utility especially in door and window frames, solid doors and windows, roofing, furniture and joinery. Since *A. robusta* has a small movement and hence high dimensional stability in service which makes it readily useful for general utility which cuts across general wood utilisation, it is thus recommended that its plantation be established to serve as substitute to traditional or primary timber species that are going into extinction.

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