*Journal of Forestry Research and Management. Vol. 16(1).31-37; 2019, ISSN 0189-8418*

*www.jfrm.org.ng*

# AXIAL AND RADIAL VARIATIONS IN THE DIMENSIONAL STABILITY OF *Elaeis guineensis* Jacq. WOOD

Areghan, S. E., *Ogutuga, S. O and Adejoba, A. L

Forestry Research Institute of Nigeria, P.M.B 5054, Jericho, Ibadan, Oyo State Nigeria,
***E-mail:** tugalord001@yahoo.com **Tel:** +2348058507670

## ABSTRACT

The introduction of Lesser-used species is as a result of the reduction in the availability of economic hard wood species also, the suitability of wood for end users has been linked with its Tangential and Radial shrinkage. This study therefore assessed the dimensional stability of *Elaeis guineensis* wood to determine its appropriate application and proper utilization. Three fully matured trees of *E. guineensis* of over 25years were selected and felled from Ogunsiji Village, Ido Local Government Area of Oyo State, Nigeria. Bolts of 50cm long were cut along the axial direction at the base (10%), middle (50%) and top (90%) from the felled trees and thereafter, converted into test samples. Samples from peripheral, centre and inner along the radial position (Across the bole) were collected for base, middle and top. Dimensional stability (shrinkage) test were carried out on the *E. guineensis* samples and data were analysed using descriptive statistics and Analysis of Variance at $P<0.05$. From the results, the mean value for Tangential shrinkage, Radial shrinkage and Volumetric shrinkage is 3.98±1.54%, 3.54±1.41% and 7.53±2.66%% respectively. Results further showed that shrinkage (tangential, radial and volumetric) increases along the axial direction (sampling height) from base to top and also increase radially from the bark (peripheral) to the inner part of the wood of *E. guineensis* . It is therefore concluded that the wood of *E. guineensis* from the base at the peripheral is more dimensionally stable than the other portions and is also suitable for building or structural application.

**Keyword:** *Elaeis guineensis*, Lesser-used species, Radial position, Axial direction, Dimensional stability, Shrinkage

## Introduction

In many developing countries, the dwindling supplies and increasing demand of tropical timber wood species necessitates the need to introduce lesser-used species to serve as substitutes. Accordingly, the utilization of lesser-used species is being promoted in many countries to reduce the pressure mounted on the forest due to felling of the few currently demanded species (Shupe *et al.*, 2005; Smith *et. al.*, 2005). The tropical forest is decreasing at an alarming rate today and the demand for wood has continued to increase in proportion to human population. Due to wood versatility and affordability over and above other construction materials, it is expected that there would be increase in the demand for wood. The high demand for wood would result in over-exploitation of both the natural and plantation forest with its attendant environmental consequences (Geomatic, 1998; Youngquist and Hamilton, 1999; Fuwape, 2001; Falemara *et al.*, 2012). The disappearance of economic hard wood species and the over exploitation of existing forest resources are of great concern to the wood scientist, technologist and users as well. The supply of quality timber from the natural forest to wood based industries is no more available in the quantities that can sustain the usual large diameter class logs required by these industries. Therefore, the promotion of *Elaeis guineensis*, a lesser-used species for use is of significant importance.

Information on the dimensional stability like shrinkage behaviour of these lesser-used species (*Elaeis guineensis*) is paramount to ensure its appropriate application and proper utilization. The dimensional stability of wood varies with species, density, direction of measurement, relative humidity, temperature, chemical composition in terms of lignin, microfibril angle, type and amount of extractives **(**Mantanis *et al.* 1994, Hernandez 2007). Shrinkage and swelling are often used to define or classify the relative dimensional stability of wood.

The changes in wood dimensions as a result of its shrinkage as it dries and swells during moisture absorption are of importance to anyone who uses wood because wood readily takes on or gives off moisture, even from the atmosphere. When wood looses moisture below Fibre saturation point (FSP), it shrinks and swells when water is absorbed. The percentage change in wood dimension as a result of moisture loss is termed shrinkage (Dinwoodie, 1989). The observed changes in wood dimension as a result of shrinkage are unequal along the three structural directions. This behaviour of wood has been documented widely by various authors (Panshin and de Zeeuw, 1980; Lausberg *et al.*, 1995; Ogunsanwo, 2000; Ojo *et al.*, 2016). Shrinking of wood can cause so many problems as wood is anisotropic in nature. It is therefore, necessary to determine the shrinkage regime of these lignocelullosic material (*Elaeis guineensis*) along the orthotropic axis and to adequately promote its proper utilization at local and international levels.

*Elaeis guineensis* (Oil palm) is a monocot species of the family, Palmaceae (Hartley, 1977). It was introduced by the Portuguese voyages to the world and originated from West Africa. Today, it can be found in Africa, America and South East Asia. Malaysia and Indonesia are the two leading countries actively planting oil palm (Balkis *et al.* 2013) out of the 24 countries that plant oil palm commercially (Edi Suhaimi *et al.* 2008). The economic life span of oil palm is 25–30 years, which is the age the palms are usually felled after the fruit or kernel productivity is no longer economical (Edi Suhaimi *et al.* 2008). However, since the fruit or kernel productivity of oil palms are uneconomical at 25–30 years, there is need therefore to carry out the effective and proper utilization of this species so as to serve as an alternative to the tropical timber wood species.

This paper, therefore, assessed the shrinkage regime of *Elaeis guineensis* in the tangential and radial directions along the height and across the bole of the species to ensure its appropriate application and proper utilization.

## Materials and Methods

Three fully matured trees of *E. guineensis* of over 25years were selected and felled from Ogunsiji Village, Ido Local Government Area of Oyo State, Nigeria located on latitude 7$^{o}$30'7.83" N and longitude 3$^{o}$47'12.81"E in April, 2015. Bolts of 50cm long were cut at the base (10%), middle (50%) and top (90%) (Sampling height) from the felled trees. The bolts were then taken to the Forest Products Development and Utilization Department of Forestry Research Institute of Nigeria, Ibadan, Nigeria for further conversion to test samples.

Samples were collected from three zones (peripheral, centre and inner) along the radial position for base, middle and top.

## Testing of the Samples

Samples were cut to 20mm x 20mm x 40mm taking into cognisance the principles of obtaining the orthogonal directions in dicot wood so, where could have been Tangential and Radial were labelled immediately as 'T' and 'R' during sawing for the Shrinkage (Tangential, Radial and Volumetric) test and samples obtained were replicated five times making 45 samples for the dimensional stability (shrinkage) test. The experimental design adopted was 3 x 3 factorial experiment in a completely randomized design (CRD).

## Determination of Shrinkage (Tangential, Radial and Volumetric)

The percentage shrinkages (S%) along the two planes were measured after specimens were oven-dried as:

$$S = \frac{D_S - D_O}{D_S} X\, 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

**Where:** $S$ = Shrinkage %, $D_S$ = dimension at Saturated Condition and $D_O$ = dimension at Oven-dry Condition.

The specimens of 20mm x 20mm x 40mm were properly aligned and coded 'T' and 'R' for tangential and radial planes respectively. They were fully immersed in water for 24hrs in order to get them conditioned to moisture above Fibre Saturated Point (FSP). After the 24hrs of full immersion in water, specimens were removed one after the other and their dimension (T and R) in wet condition were taken to the nearest millimetre using a digital Vernier calliper and recorded.

$$VS = S_R + S_T \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

**Where:** $VS$= Volumetric Shrinkage, $S_R$ = Radial Shrinkage and $S_T$ = Tangential Shrinkage.

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

## Data analysis

Analysis of variance in 3 x 3 factorial experiment in a completely randomized design (CRD) was carried out to determine if the sampling height and radial position had significant effects on the dimensional stability (shrinkage) of the *E. guineensis* wood. Duncan Multiple Range Test (DMRT) at 5% probability level was used to compare means.

## Results and Discussion

**Table 1: Mean Shrinkage and Follow-up Test of *Elaeis guineensis* Wood Samples**

| | | **Radial Position (Across the Bole)** | | | |
|---|---|---|---|---|---|
| **Shrinkage Test** | **Sampling Height** | **Peripheral** | **Centre** | **Inner** | **Mean** |
| **TS (%)** | **Base** | 2.07 | 3.20 | 4.71 | $3.33\pm1.21^{b}$ |
| | **Middle** | 2.71 | 3.50 | 5.38 | $3.86\pm1.36^{b}$ |
| | **Top** | 3.40 | 4.47 | 6.42 | $4.76\pm1.73^{a}$ |
| **Mean** | | $2.73\pm0.88^{c}$ | $3.72\pm1.15^{b}$ | $5.50\pm1.05^{a}$ | **3.98±1.54** |
| **RS (%)** | **Base** | 1.69 | 2.93 | 4.41 | $3.01\pm1.42^{b}$ |
| | **Middle** | 1.95 | 3.32 | 5.21 | $3.49\pm1.48^{b}$ |
| | **Top** | 3.12 | 4.19 | 5.08 | $4.13\pm1.17^{a}$ |
| **Mean** | | $2.25\pm0.76^{c}$ | $3.48\pm0.93^{b}$ | $4.90\pm1.02^{a}$ | **3.54±1.41** |
| **VS (%)** | **Base** | 3.77 | 6.13 | 9.12 | $6.34\pm2.32^{c}$ |
| | **Middle** | 4.66 | 6.82 | 10.58 | $7.36\pm2.56^{b}$ |
| | **Top** | 6.52 | 8.66 | 11.50 | $8.89\pm2.59^{a}$ |
| **Mean** | | $4.98\pm1.35^{c}$ | $7.20\pm1.72^{b}$ | $10.40\pm1.26^{a}$ | **7.53±2.66** |

Means ± Standard Deviation of five replicate samples

### Tangential Shrinkage (TS)

The mean value for Tangential Shrinkage (TS) of *E. guineensis* was 3.98±1.54%, which ranged between 3.33±1.21%, 3.86±1.36% and 4.76±1.73% for base, middle and top respectively (Table 1). This shows that TS increase from base to top axially. Radially, TS increases from the peripheral (bark) to the inner part of the wood of *E. guineensis* ranging from 2.73±0.88%, 3.72±1.15% and 5.50±1.05% across the bole for peripheral, centre and inner wood respectively (Table 1). The result further shows that TS increase from peripheral to the inner wood. It was observed that the lowest TS values were obtained at the base and the peripheral. These findings are similar to that of Ogunsanwo and Ojo (2011) and Ojo *et al.* (2016) who reported 3.84% and 3.71% for the mean TS of *Borassus aethiopum* respectively. The mean TS obtained in this research is also lower than the 4.37% reported by Ogutuga *et al.*, (2016) for the mean TS of thermal treated bamboo glu-lam.

In general, a consistent trend was noticed from the base to the top of the wood of *E. guineensis*. However, it was at variance with the findings of Ogunsanwo (2000) on *Triplochiton scleroxylon* and Poku *et al.* (2001) on *Petersianthus macrocarpus* and *Ricinodendron heudelotti* from Ghana. They observed that the values increased from the base to the top and a sharp decrease from the centre to the bark of the species.

The result of analysis of variance for TS presented in Table 2 shows that the differences in sampling height and radial position had significant effect on TS while, the levels of interaction between the sampling height and radial position had no significant effect (P<0.05). The follow up test (Table 1) revealed that samples obtained from the base at the peripheral position were more dimensionally stable than other samples obtained from the middle and top as well as from the centre and inner position of *E. guineensis*.

**Table 2: Result of the Analysis of Variance for Shrinkage of *Elaeis guineensis* Wood Samples**

| Source of variation | Df | TS Sig. | TS | RS Sig. | RS | VS Sig. | VS |
|---|---|---|---|---|---|---|---|
| **Sampling Height** | 2 | 0.000 | 10.04* | 0.002 | 7.39* | 0.000 | 23.86* |
| **Radial Position** | 2 | 0.000 | 37.59* | 0.000 | 40.94* | 0.000 | 106.71* |
| **Sampling Height * Radial Position** | 4 | 0.965 | $0.14^{ns}$ | 0.471 | $0.91^{ns}$ | 0.815 | $0.39^{ns}$ |
| **Error** | 36 | | | | | | |
| **Total** | 44 | | | | | | |

* Significant at P= 0.05, ns not significant at P=0.05

### Radial Shrinkage (RS)

The mean radial shrinkage was 3.54±1.41% with a range value of 3.01±1.42%, 3.49±1.48% and 4.13±1.17% along the bole for base, middle and top respectively (Table 1). Across the bole, RS ranged from 2.25% to 4.90% from the bark (peripheral) to the innermost part (Table 1). It was observed that RS increase from base to top and towards the innermost part from the bark as in the case of tangential shrinkage. The findings of this study are in line with the work of Akira (1978), who observed 3.60% for the species from Gold Coast (Ghana), Guinea, Sudan and Kenya and also with that of Ogunsanwo and Ojo (2011), who observed 3.66% for *B. aethiopum*. Ogutuga *et al*. (2016) reported RS mean value of 3.15% for thermal treated bamboo glu-lam, which is slightly lower than the mean value for RS reported in this study.

Result of analysis of variance for radial shrinkage revealed that both sampling height and radial position are significantly different at 5% level of probability. Effect of interaction between radial and sampling position was not significantly different at this level as shown in Table 2. The follow up test further revealed that sampling height and radial position were different from one another (Table 1).

## Volumetric Shrinkage (VS)

The mean value recorded for VS was 7.53±2.66% ranging between 6.34±2.32%, 7.36±2.56% and 8.89±2.59% along the sampling height for base, middle and top respectively and 4.98±1.35%, 7.20±1.72% and 10.40±1.26% across the bole for peripheral, centre and inner respectively (Table 1). These agrees with the mean VS (7.51%) recorded by Poku *et al.,* (2001) for *Alstonia Boonei*. They also recorded mean VS of 6.21% and 11.51% for *Ricinodendron hendelotti and Petersianthus macrocarpus* respectively. The differences in the mean VS recorded in this study and ones recorded by Poku *et al.* (2001) for *R. hendelotti and P. macrocarpus* could have been attributed to the nature of the wood and probably the presence of more biomass in the latewood cells as noted by Chudnoff (1976). It was also observed that, VS increased from the base to the top of the *E. guineensis* trunk. Radially, it increased from the peripheral to the centre and then to then innermost part of the *E. guineensis.* These trend of variations in VS from base to top and peripheral to inner wood might be due to the rapid reduction of the microfibrillar angle in the cell wall and the cellulose content (Panshin and de Zeeuw, 1980).

The Analysis of variance result for VS shows that the differences in sampling height and radial position had a significant effect on VS of the *E. guneensis* samples while, their levels of interaction had no significant effect at P<0.05 (Table 2). The follow up test further revealed that sampling height and radial position were different from one another (Table 1) with the samples from the base and the peripheral having better VS.

## Conclusion

Dimensional stability was influenced by sampling height and radial position. Tangential shrinkage and Radial shrinkage increased consistently from the base to the top and also increased significantly across the bole from the peripheral to the inner part of the *E. guineensis* wood. Tangential shrinkage and radial shrinkage values are not too different from each other unlike in dicot trees that tangential shrinkage is always twice the radial shrinkage. The wood of *E. guineensis* from the base at the peripheral is more dimensionally stable than the wood from other portions and could be better utilized for building or as a structural material.

## References

Akira Takahashi, (1978). Compilation of Data on the Mechanical Properties of Foreign woods. No 7, Part III (Africa). January, 1978. A monograph published by Matsue: Shimane University.

Balkis Fatomer A. Bakar , Paridah Md Tahir , Alinaghi Karimi , Edi Suhaimi Bakar , Mohd KhairunAnwar Uyup and Adrian Cheng Yong Choo (2013). Evaluations of some physical properties for oil palm as alternative biomassresources, Wood Material Science & Engineering, 8:2, 119-128, DOI: 10.1080/17480272.2012.701666

Chudnoff, M. (1976). Density of tropical timbers as influence by climatic life zones. Commonwealth Forestry Review. 55 (3):203-217.

Dinwoodie, J. M. (1989). Wood: Nature's cellular, polymeric fibre composite. Pub. *The Institute of Metal London.* Pp 190.

Edi Suhaimi Bakar, Mohd. Hamami Sahri, and Paik San H'ng (2008). Anatomical Characteristics and Utilization of Oil Palm Wood. In The Formation of Wood in Tropical Forest Trees: A Challenge from the Perspective of Functional Wood Anatomy (Tadashi Nobuchi and Mohd. Hamami Sahri (editors)). Pp 161- 180.

Falemara, B.C., Ampitan, T.A., Ukanyirioha, C. J. and Udenkwere, M. (2012). Consciousness and the challenges of sustainable forest management. Reorganizing Nigeria Forestry in the Rapidly Changing Climatic Conditions: Challenges and Solutions. Proceediing of the 2nd annual conference of the Association of women in Foretsry and Environment (AWIFE) held at Forestry Research Inst. Of Nigeria, Ibadan, 6th Nov. pg 119-125.

Fuwape, J.A. (2001). The Impacts of Forest Industries and Wood Utilization on the Environment.Forestry Workshop. 6-7 December, 2001.

Geomatics, (1998). A report of forest resources study in Nigeria. Submitted to Forest Management and Co-ordinating Unit. Geomatics Nigeria limited Akure. 60pp.

Hartley, C.W.S. (1977). The Oil Palm (Elaeis guineensis Jacq.). 2nd Ed. Longman. London. 806pp.

Hernandez, R.E. (2007). Swelling properties of hardwoods as affected by their extraneous substances, wood density and interlocked grain. *Wood and Fiber Science* 39: 146– 158.

Lausberg, M. J. F., Cown, D. J., MacConchie and Skipmith, J. H. (1995). Variation in some Wood Properties of *Pseudotsuga menziensii.* Provenancies grown in New Zealand". *New Zealand Journal of Forestry Scienc*e 25 (2): 133-146.

Mantanis, G.I., Young, R.A. & Rowell, R.M. (1994). Swelling of wood. Part I: swelling in water. *Wood Science and Technology* 28: 119–134.

Ogunsanwo, O.Y. (2000). Characterization of Wood Properties of Plantation grown Obeche (*Triplochiton sceleroxylon.* K. Schum) in Omo Forest Reserve. Ogun State, Nigeria, Ph.D Thesis in the department of Forest Resources Management. University of Ibadan. Pp 253.

Ogunsanwo, O. Y and Ojo, A. R. (2011). Density and Dimensional stability of *Borassus aethiopum* (Mart) Wood from A derived savannah zone in Nigeria. *Nigeria Journal of Forestry. Vol. 43.* pp 31-38.

Ogutuga, S.O., Ogunsanwo, O.Y., Ojo, A.R. and Adebayo, S.O. (2016). Effect of Laminate Thickness on Selected Physical Properties of Thermal Treated Bamboo Glu-Lam. Proceedings of the 5th Biennial Conference of the Forest & Forest Products Society held at Delta State University, Abraka, Asaba Campus, Asaba, Nigeria between 25th - 29th April, 2016. (Adekunle, V.A.J., Oke, D.O. and Emerhi, E.A. - Editors). Pp 505- 511.

Ojo, A. R., Ogunsanwo, O. Y. and Adebayo, S. O. (2016). Intra-Tree Variations of the Dimensional Stability Along the Orthotropic Directions of the Wood of *Borassus aethiopum* Mart. in Different Ecological Zones in Nigeria. Proceedings of the 1st Commonwealth Forestry Association (CFA) Conference, Nigeria Chapter held at Forestry Research Institute of

Nigeria (FRIN), Jericho, Ibadan, Nigeria, between 10th and 12th October, 2016. (B. O. Agbeja, A. C. Adetogun, O. R. Adejoba & I. O. Osunsina- Editors). Pp. 244 – 252.

Panshin, A. J and de Zeeuw. C. (1980). Textbook of Wood Technology. 4th Edition MacGraw-Hill Book Company. Pp722.

Poku, K., Qunglin, Wu and Richard, Viosky. (2001). Wood Properties and their variations with the tree stem of lesser-used species of Tropical hardwood from Ghana. *Wood and Fibre Science. Journal of the society of wood science and Technology*. Vol.33, No22; 284-291.

Shupe, T. F., Aguilar, F. X. and Moslcy, R. P. (2005). Wood properties of selected lesser used Honduran wood species. *Journal of Tropical Forest Science* 17 (3): 438-446.

Smith, R.L., McDaniel, P. W. and Fell, D. (2005). Opportunities for the utilization of alternative species in secondary wood manufacturing. *Forest Prod. J.* 55 (4): 71-77.

Youngquist, J.A. and Hamilton, T.E. (1999). Wood Products A call for Reflection and Innovation. Forest Products Journal 49 (11/12): 18-27.