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CELL MORPHOLOGICAL STUDIES OF *Artocarpus altilis* (PARKINSON EX. ZORN) FORSBERG WOOD

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Abstract:
This study investigated fibre characteristics and morphological indices of Artocarpus altilis, a lesser used species (LUS) wood which is fast becoming popular in Nigeria, due to its excellent performance in light structural applications, aesthetic and dimensional stability. Not to limit its uses to furniture production. Axial and radial examinations of fibre characteristics of naturally grown wood of Artocarpus altilis were evaluated to determine its suitability as pulp wood. Four matured tree of 45±5 years were purposively selected and felled. Billets of 500cm were obtained from base, middle and top (10,50 and 90%) of the merchantable height of each selected tree, partitioned into corewood, innerwood and outerwood and further processed into 20x20x20mm^3 *wood samples using ASTM procedure. Data were analysed using descriptive and inferential analysis at α0.05. The basic wood density of Artocarpus altilis mean is 581kg/m*^{3}*. The fibre characteristic showed that mean fibre length, fibre diameter, lumen width and cell wall thickness (CWT) were (1.52±0.28mm, 35.09±7.56µm, 22.95±7.89µm and6.11±0.68µm) respectively. The derived indices like Slenderness, Flexibility, Runkel Ratio, Rigidity Coefficient, Form factor and Muhlsteph ratio had means 44.79±11.49, 63.59±8.49, 0.60±0.23, 0.18±0.04%, 250.73±53.25 and 58.86±10.62% respectively. The result from this study compared favourably with those of known wood species such as Gmelina arborea. This indicates that intra and inter variation between axial and radial direction does not have negative influence on any part of the species from been used. However, all the fibre features considered were observed to be suitable for pulp and paper making.*

Key words: *Artocarpus altilis; lesser-used species (LUS)*; *cell morphology; density; fibre*.

INTRODUCTION

In Nigeria, the demand for wood and wood-based products, including pulp and paper is on the increase while one of the problems in pulp and paper industry is an inadequate supply of long fibre for paper production (Osadare 1993, Oluwadare 2007). According to (Okojie *et al*. 1995), about 4,600 plant species were recorded in Nigeria. Akachuku (1997) reported that over 560 tree species in Nigerian forest can attain a height of at least 12m and a girth of 60cm when matured. Akinsanmi and Akindele (2002) also confirm the natural forests consisting of a wide variety of species and sizes of great attraction. However, these enormous resources in the tropical rainforest constituting a vital asset to the country have not been properly assessed. Pressure upon the natural forest which has been the resource-based for this industry has been depleted owing to population explosion and industrialization both in urbanization and economic development (Shakhes *et al*. 2011; Izekor 2010; FAO 2001; Fuwape and Fabiyi 2003). Scarcity of economic species known to be suitable for wood pulp had made pulp and paper industries among other factors none functioning in Nigeria.

However, (Adi *et al*. 2014, Istikowati *et al*. 2014, 2016) reported that utilization of wood resources from several fast-growing tree species is limited because little information is available regarding the properties and anatomical characteristics of the wood. Investigation on wood characteristics and the corresponding pulp properties for three unutilized fast-growing tree species such as terap (*Artocarpus elasticus*), medang (*Neolitsea latifolia*) and balik angin (*Alphitonia excelsa*). However, further research is required to characterize the potential wood resources from other unutilized fast-growing tree species. The wood properties required to evaluate fiber morphology for pulp and paper qualities including anatomical characteristics (Pirralho *et al*. 2014, Istikowati *et al*. 2016). Thus, analysis of fibre characteristics such as fibre length, fibre diameter, lumen width, cell-wall thickness, and derived morphological factors became important in estimating pulp quality of fibre (Dinwoodie 1989). One of the first fibre properties related to strength properties was fibre length (Oluwadare *et al*. 2007) while pulp and paper quality, based on wood properties like anatomical characteristics, can be estimated from the derived indices: Runkel ratio (Runkel 1949), Luce ' s shape factor (Luce 1970), flexibility coefficient (Malan and Gerischer 1987), Slenderness ratio (Malan and Gerischer 1987), solids factor (Barefoot *et al*. 1964). With the wood-fibre-crisis envisaged by experts and the need to meet future fibre supply occasioned by the ever-increasing demand for pulp and paper products globally, it is imperative to beam searchlight on lesser-used wood species to screen them for pulp and paper making. Moreover, more use of LUS may contribute towards efficient forest management sustainability and utilization of the tropical forest area (Poku *et al*. 2001). Researchers have identified suitable species for pulp and paper products, food plants, medicinal plants and forage plants from an investigation carried out by (Ogunwusi 1991; Osadare 1993; Osadare 2001; Ogunnika 2001; Ogunnika and Kayode 2002).

Artocarpus altilis is a lesser-used species belonging to the genus Artocarpus (Moraceae) comprises approximately 50 species and is widely distributed in tropical and subtropical regions. The generic name of the species comes from the Greek words 'artos' (bread) and 'karpos' (fruit) and the fruits eaten are commonly called breadfruit. It was therefore chosen for evaluation because of its large size of up to 25m (82f) or more in height. The species is popular as an agroforestry species planted as a fruit tree and recently as good construction timber. Recent surveys of the timber market in the southwest zone of Nigeria shows a good representation of this emerging species.

Available information has shown that, despite the abundance of this species, it remained unattended to in terms of properties evaluation and very little research has been carried out on *A. altilis* (Park) Fosberg wood in the Country. This is why the study intends to investigate the wood suitability for various uses to compliment the commercial wood in Nigeria by assessing its cell morphological characteristics.

OBJECTIVE

The objective of this study is to examining the fibre dimension characteristics and properties of derived morphological indices of *Artocarpus altilis* wood to explore the possibility of using this LUS species as a substitute for paper production material.

MATERIALS AND METHODS

Four matured trees of *Artocarpus altilis* were purposively selected based on the absence of reaction tendencies, fairly straight and free from natural defects as well as excessive knot are harvested. Age and diameter sizes of the trees were considered based on the farmer's information and growth ring counts at Longe village, Gambari Forest Reserve, Oyo State. It lies within latitude 7°10'37" N to 7°10'34" N and longitude 3°52'50" E and 3°50'59" E. Three billets of 500cm were obtained from base, middle and top (10, 50 and 90%) of the merchantable height of each selected tree making a total of (12) bolts.

Sample preparation

Test sample representatives were taking from the Central planks obtained from all the bolts to give 12 planks from where test samples were obtained. The central planks were further partitioned into corewood, innerwood and outerwood along the radial planes according to the method used by Ogunsanwo and Onilude (2001) and Shupe *et al*. (1995). Wood samples were further processed into standard dimensions for determination of wood properties. 20x20x60mm dimension was used for basic wood density determination while 20x20x20mm dimension for fibre characteristics and its derived values determination according to ASTM, 1991 (Fig. 1).

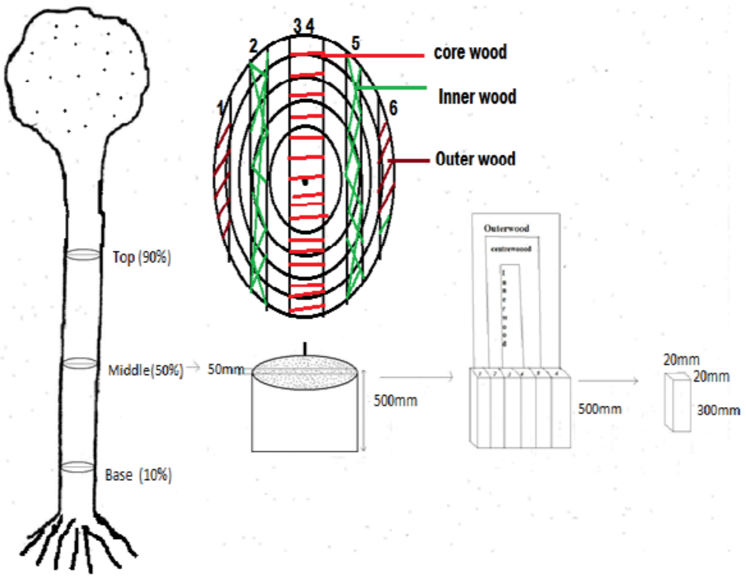

Fig. 1.* *Showing schematic sampling procedure for obtaining test samples for basic density and fibre characteristics.

Physical properties

Basic Density Determination

360 test sample of dimension (20x20x60)mm^3 were produced from the central planks obtained at each sampling height (base, middle and top) for each trees and partitioned from pith to bark to make five (5) test samples from each of the sampling position. Therefore, 30 test samples were obtained for each replicate to make 90. Samples were oven-dried at 103±20C to a constant weight temperature, after which the oven dried weight was measured and also the oven dry volume was determined as prescribed by Smith (1954) on a sensitive G and G Measuring scale following ASTM D 2395-17 (2017).

where:

$$D = \frac{\text{oven dry weight}}{\text{oven dry volume}} \qquad 1$$

Cell Morphological Determination

Fibre characteristics and its derived values

Small wood slivers were obtained each from different sampling height. The slivers were placed in an equal volume (1:1) of 30% hydrogen peroxide and 10% glacial acetic acid, boiled in the oven for 16hours at 105ºC until it bleached white and soft (ASTM D 1413-61 2007). The slivers was decanted and then washed, placed in 30ml-test tubes with 20ml-distilled water and shaken vigorously to separate the fibre bundles into defibrised fibres. The macerated fibre suspension was carefully aligned on a slide using a rubber teat. Fibre dimensions were measured in swollen condition using X10 magnifications on Rheichert Visopan microscope screen to measure twenty five fibres for fibre length (L), fibre diameter (FD), lumen width (LW) and cell wall thickness (CWT), this were further calculated using appropriate formulae based on Oluwadare (2007) while the derived morphologies followed the method used by (Saikia *et al.* 1997; Ogbonnaya *et al*. 1997; Ververis *et al*. 2003; Oluwadare and Sotannde 2006; Tutus *et al.* 2010). Thereafter, it was compared with standards from softwoods and hardwoods as related to that of *Gmelina arborea* which is the reference material in determining the suitability of a material for pulp and paper making based on (Anon 1984; Fuwape 1991) observations. Hence, the fibre characteristics and their derived morphologies are presented in Table 1.

Table 1

Showing the derived morphologies parameters and formulas

Slenderness Ratio	$\text{Slenderness} = \frac{\text{Fibre length}}{\text{Fibre diameter}}$	(2)
Flexibility power	$\text{Flexibility power} = \frac{\text{Lumen width}}{\text{Fibre diameter}} \text{ x} \frac{100}{1}$	(3)
Runkel Ratio	$\text{Runkel ratio} = \frac{\text{2 x cell wall thickness}}{\text{lumen width}}$	(4)
Coefficient of rigidity	$\text{Coefficient of rigidity} = \frac{\text{Cell wall thickness}}{\text{Fibre diameter}}\, x \frac{100}{1}$	(5)
Form factor	$\text{F} - \text{factor} = \frac{\text{Fibre length}}{\text{Fibre cell wall thickness}}$	(6)
Muhlsteph ratio	$\text{Muhlsteph ratio} = \frac{\text{Fibre width}^2 - \text{lumen width}^2}{\text{Fibre width}^2} \text{ x } 100$	(7)

RESULTS AND DISCUSSION

Basic density obtained in this study was 581.48±57.61kg/m^3 and slightly higher than Chudnoff (1980) (400-480kg/m^3), Ajala and Ogunsanwo (2011) (430kg/m^3) obtained for *A. robusta.* The result obtained followed the research findings reported by (MTC 2018) 400-560kg/m^3, (Rincon *et al*. 2004; Orwa *et al*. 2009; Ragone 2011) and in line with what observed for *A. altilis*, 505-645kg/m^3 at 15% MC, Richter and Dallwitz (2000). The basic wood density decreases from base (602.74±64.48kg/m^3) to top (570.70±56.02kg/m^3) and decrease from corewood to outerwood as presented in Fig 3. This corroborate Tsoumis (1991) who stated that as moisture content increases, the density of wood also increases and as the density of wood in axial direction has a tendency for reduction from base to top of the tree stem (Tsoumis 1991). A greater density at the base of a tree is contributed by the formation of heartwood where the proportion of heartwood is higher than the proportion of sapwood. The basic density at the upper of the tree is lower because of influence by the presence of juvenile wood around the pith in vertical variation. Philips (1941) reported that density is a measure of the cell wall material per unit volume and as such gives a very good indication of the strength properties and expected pulp yields of timber

FIBRE DIMENSIONS

Table 2 shows the fibre characteristic values that variations existed in fibre dimensions both radially and axially. The mean Fibre length (1.52±0.28mm), Fibre diameter (35.09±7.56µm), Lumen width (22.95±7.89µm) and cell wall thickness (CWT) (6.11±0.68µm) while FL, FD and CWT significantly decreased from base (1.58±0.28mm, 37.03±9.22µm, 6.23±50.75µm) to top (1.48±0.19mm, 34.70±7.67µm, 5.88±0.53µm) respectively and ranged from corewood (1.53±0.23mm, 44.77±10.29µm, 6.52±0.17µm) to outerwood (1.37±0.18mm, 37.16±3.48µm, 6.08±0.26µm) but lumen width increased from base (22.49±8.54µm) to top (23.36±7.53µm) and ranged from corewood (18.80±4.96µm) to outerwood (20.18±6.28µm) as presented in Fig. 2(a-d).

Mean fibre length was 1.52mm, *A altilis* species show short fibre length based on the mean fibre length that was lower than 1.60mm because any fibre below 1.60mm are classified as short while that above 1.60mm are considered long (Anon 1984). Some authors also observed similar fibre lengths of less than 1.60mm in some Nigerian hardwood timbers. Oluwadare (2007) reported 0.65mm for *Leucaena leucocephala* and Ogunjobi *et al*. (2014) for *Vitex doniana.* According to Oluwadare (2007), reported that 1.60mm is an acceptable range of values for hardwoods for papermaking.

In this present study, fibre diameter along the sampling height decreases from base to the middle and marginal increase to the top, likewise, increase at the core wood to the inner wood and decreases to the outer wood, hence, both sampling height and radial position did not exhibit a specific pattern of variation. Roger *et al.* (2007) reported that the average fibre diameter increase with an increase in tree age. The decrease in fibre diameter as the tree growing to maturity might be due to the molecular and physiological changes that occur in the vascular cambium during the tree aging process and increase in wood cell wall thickness (Plomion *et al.* 2001).

Lumen width increases from base to the top and this could largely due to increasing in lumen width with decreasing age of the tree be due to a decrease in cell size and physiological development of the wood as the tree grows in diameter and be a fruit tree, this is similar to observed variations reported by Izekor (2010) in *Tectona grandis* wood, Ogunjobi *et al.* (2014) in *Vitex doniana* and, (Oluwadare and Sotande 2007) in *Leucaena lencocephala* wood. This similar observation was reported by (Ogunsanwo 2000) for *Triplochiton scleroxylon*. This increase in cell wall thickness in the axial direction and decrease at radial direction of *A. altilis* wood could be as a result of the rapid cell division of cambium as the tree grows in girth (Roger *et al.* 2007). The CWT positively affects the bursting and tensile strength and folding endurance characteristic of the paper, hence, *A. altilis* would have high strength from the paper produced.

Table 2

Mean values of Basic Density, FL, FD, LW and CWT along sampling height and radial position

Sampling Height	Radial Position	Density Mean±SD (kg/m^3)	FL (mm)	FD (µm)	LW (µm)	CWT (µm)
Base	Corewood	590.41±59.4	1.53±0.23$_b$	44.77±10.3$_a$	27.12±10.84$_a$	6.52±0.17$_a$
	Innerwood	581.28±64.9	1.63±0.34$_a$	34.76±4.67$_{ab}$	21.54±8.24$_b$	6.12±0.49$_b$
	Outerwood	629.28±54.3	1.58±0.32$_{ab}$	31,57±7.02$_b$	18.80±4.96$_c$	6.05±0.33$_c$
Pooled Mean		**602.67±59.47**	**1.58±0.28**	**37.03±9.22**	**22.49±8.54**	**6.23±0.75**
Middle	Corewood	572.67±49.93	1.33±0.23$_c$	36.23±5.34$_a$	25.34±3.85$_a$	6.07±0.67$_c$
	Innerwood	569.56±58.57	1.63±0.41$_a$	32.60±4.58$_b$	20.16±5.74$_c$	6.27±0.56$_b$
	Outerwood	570.79±44.02	1.52±0.36$_b$	31.84±4.61$_b$	23.55±10.55$_b$	6.37±0.68$_a$
Pooled Mean		**571.01±47.36**	**1.49±0.35**	**33.55±5.09**	**23.01±7.89**	**6.23±0.71**
Top	Corewood	570.52±86.45	1.37±0.18$_c$	37.16±3.48$_a$	27.22±8.23$_a$	5.72±0.68$_b$
	Innerwood	562.56±30.57	1.49±0.13$_b$	32.13±5.86$_c$	22.67±4.67$_b$	5.87±0.43$_b$
	Outerwood	579.02±54.33	1.58±0.20$_a$	34.84±8.94$_b$	20.18±6.28$_c$	6.08±0.26$_a$
Pooled Mean		**570.70± 56.02**	**1.48±0.19**	**34.70±7.67**	**23.36±7.53**	**5.88±0.53**
Mean		581.48±57.61	**1.52±0.28**	**35.09±7.56**	**22.95±7.89**	**6.11± 0.68**

Means± standard error of the mean of 5 replicate samples. Values with the same alphabet in each column are not significantly different at α = 0.05 using Duncan multiple range test.

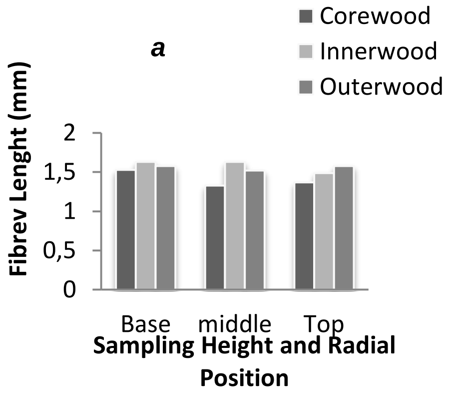

Fig. 2.a
Mean values of FL along SH and RP.

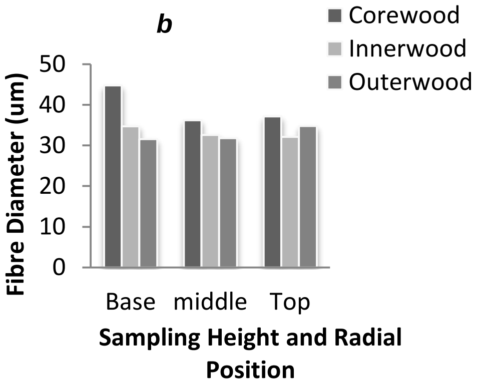

Fig. 2.b
Mean values of FD along SH and RP.

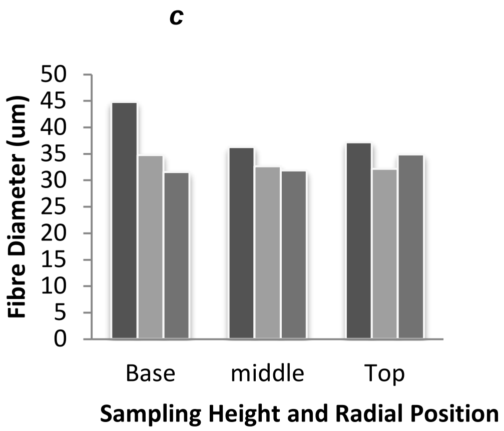

Fig. 2.c
Mean values of LW along SH and RP.

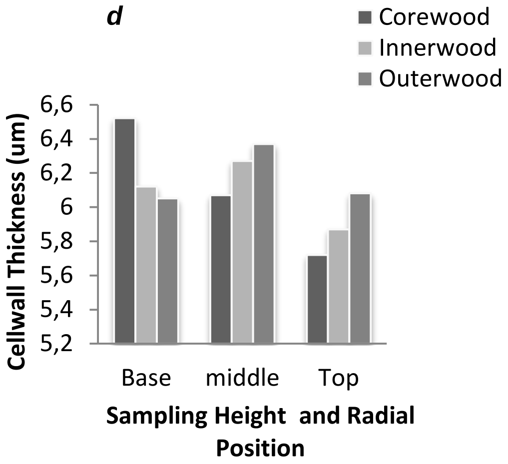

Fig.2.d
Mean values of CWT along SH and RP.

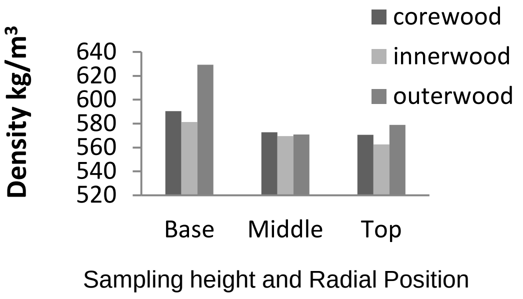

Fig. 3.
Mean values of density along SH and RP.

DERIVED MORPHOLOGY

Table 3 shows the mean values for derived morphology assessed are Slenderness, Flexibility, Runkel Ratio, Rigidity Coefficient, F-factor and Muhlsteph ratio with 44.79±11.49, 63.59%, 0.60±0.23, 0.18±0.04%, 250.73±53.25 and 58.86±10.62% respectively and as presented in Fig. 4(a-f).

Slenderness ratio is a factor that determines the fitness of wood material to paper manufacturing which is evaluated by relating fibre length to fibre diameter Akgul (2009). According to Sharma *et al.* (2013) opined that for a suitable pulp and papermaking, the slenderness ratio must be more than 33 because high SR in fibre will produce a higher rate of tear resistance in a paper (Akpakpan *et al*. 2012). However, the values for SR fibres in this study is more than required slenderness ratios of 33, therefore, *A. altilis* wood can produce good and strong papers. Flexibility is one of the most important derived parameters in determining the strength properties of paper and is the ratio of lumen diameter and fibre diameter. Flexibility defines the degrees of fibre bonding in paper sheet produced (Akpakpan *et al.* 2012). Smook (2003) classified suitable flexibility coefficient values for both hardwood and softwood is between 55-70% and 55-75% respectively. The fibres that have flexibility coefficient of more than 75% are usually categorized as highly elastic while those falls between 55-75% are considered to be elastic (Bektas *et al.* 1999). Singh *et al*. (2011) reported that fibres with high flexibility coefficient values will readily collapse during paper manufacturing, having a large surface area for bonding and consequently produced paper with good strength. Hence, the flexibility coefficient values obtained in this study is considered to be flexible and satisfies requirements for pulp and paper manufacturing.

Runkel ratio is considered to be a significant parameter for pulp and paper properties in expressions of similarity and pulp yield (Ohshima *et al.* 2005). It measures the proportion ratio of cell-wall thickness to the lumen width of the fibre. Runkel ratio across and along the wood always varied. When the ratio is less than 1 is a suggestion that such wood is suitable for papermaking. Hence, the lower this value, the thinner the fibre cell walls and the better is the fibres for papermaking (Istek 2006; Oluwadare and Sotannde 2007). The outer-wood recorded higher Runkel ratio which is within the accepted limit to manufacture absorbent papers (Dutt and Tyagi 2011). This is in line with the research report for *Leucaena leucocephala* (0.59) (Oluwadare and Sotannde 2007), *Vitex doniana* (0.84) (Ogunjobi *et al*. 2013), *Anogeissus leiocarpus* (0.85) (Ogunjobi, *et al*. 2014) *Eucalyptus camaldulensis*, (0.65) (Manahil and Abdelazim 2015) and in *F. exasperata* (0.79) (Anguruwa 2018).

Rigidity coefficient is an important factor that controls flexibility and coarseness of the wood fibre. Dutt and Tyagi (2011) reported that fibres with low rigidity coefficient give a higher degree of conformability within the sheet, which produces the sheet of lower bulk or higher density with resultant effects that paper produced from such fibres will give good physical strength properties with high brightness and low porosity and appropriate for printing, writing, packaging and wrapping purposes. Rigidity coefficient of *A. altilis* was 0.18, compared favourably with the report of Oluwadare and Sotannde (2007) 0.19 for *Leucaena leucocephala* and Anguruwa (2018) 18.84 for *Ficus exasperata*. This makes *A. altilis* wood more suitable and appropriate raw material for pulp and papermaking.In this present study, F-factor was 250.73; this value is in line with the research report of Akgul and Tozluogu (2009) for *Fagus orientalis* and *Pine nigra* wood was 140.38 and 240.55 respectively. F-factor is determined by dividing fiber length to wall thickness; this shows that flexibility of papers obtained from fibers with bigger F-factor is considered to be good. According to the criteria of fiber quality and quality class II reported by Agul and Tozluogu (2009).

Muhlsteph's proportion of *A. altilis* is 58.86% which falls within this class. Muhlsteph values slightly lower than what was obtained 61.2 for Pinus brutia (Bektas *et al*. 1999), 76.68 for Fagus orientalis, (Agul and Tozluogu 2009), but slightly higher than what was obtained in *Pine nigra* wood 47.28, (Agul and Tozluogu 2009), 52 obtained in *Shorea mujongensis* (Listya and Supartini 2011). Similarly, 46.17 for Acacia hybrid, 45.85 for *A. margium* and 55 for *A. auriculiformis* (Yahaya *et al*. 2010) and 57.39 obtained for *F. exasperata.* (Anguruwa 2018) When a lower value is obtained from wood fibres, it depicts that such fibre is thinner cellwall, and thin wall fibers can easily be crushed on paper production which eventually affects the density of paper produced and tear resistance properties positively. Hence, the use of thin wall fibres is more preferable in the paper industry among which *A.altilis* species can be categorized. Hence, According to (Oluwadare 1998), these values are of the acceptable range for hardwoods for papermaking.

Table 3

Mean values of Derived Fibre Morphology

SH	RP	Slenderness	Flexibility (%)	Runkel Ratio	Rigidity Coefficient (%)	F-Factor	Muhlsteph Ratio (%)
Base	Corewood	35.13±6.9$_c$	69.44±9.3$_a$	0.46±0.2$_c$	0.15±0.1$_b$	240.28±55.1$_c$	51.11±12.5$_c$
	Innerwood	47.25±8.9$_{ab}$	64.34±4.2$_b$	0.56±0.1$_b$	0.18±0.2$_{ab}$	264.58±37.3$_a$	58.41±5.5$_b$
	Outerwood	51.18±10.5$_a$	59.96±10.$_c$	0.71±0.3$_a$	0.20±0.1$_a$	261.95±50.9$_b$	63.25±12.5$_a$
Pooled Mean		**44.52± 10.9**	**64.57± 8.6**	**0.58± 0.2**	**0.18± 0.04**	**255.60± 46.59**	**57.60± 11.04**
Middle	Corewood	37.09±7.3$_c$	65.73±7.4$_a$	0.55±0.2$_b$	0.18±0.1$_b$	220.73±46.20$_c$	56.25±9.1$_b$
	Innerwood	50.86±12.3$_a$	60.29±8.6$_b$	0.69±0.3$_{ab}$	0.19±0.1$_b$	262.97±76.22$_a$	63.09±10.2$_{ab}$
	Outerwood	48.30±12.8$_b$	59.21±8.7$_b$	0.72±0.3$_a$	0.22±0.1$_a$	243.61±92.75$_b$	64.37±10.1$_a$
Pooled Mean		**45.41± 12.64**	**61.74± 8.2**	**0.65± 0.24**	**0.19± 0.04**	**242.43c 63.96**	**61.23± 9.76**
Top	Corewood	37.11±6.0$_b$	68.67±6.3$_a$	0.47±0.1$_c$	0.16±0.1$_b$	246.84±60.7$_b$	52.47±8.8$_b$
	Innerwood	47.41±9.2$_{ab}$	62.40±7.9$_b$	0.63±0.2$_{ab}$	0.19±0.1$_{ab}$	255.76±34.2$_b$	60.56±9.9$_a$
	Outerwood	48.76±13.6$_a$	62.30±9.8$_b$	0.65±0.3$_a$	0.19±0.0$_a$	259.87±36.2$_a$	60.21±12.1$_{ab}$
Pooled Mean		**44.43± 11.31**	**64.46± 8.6**	**0.72± 0.24**	**0.18±0.04**	**254.15± 48.8**	**57.74± 11.05**
Mean		**44.79±11.49**	**63.59±8.46**	**0.60±0.23**	**0.18±0.04**	**250.73± 53.25**	**58.86±10.62**

SR: Slenderness ratio, FR: Flexibility ratio, RR: Runkel ratio, CR: Coefficient of rigidity.
Means ± standard error of the mean of 5 replicate samples. Values with the same alphabet in each column are not significantly different at α = 0.05 using Duncan multiple range test.

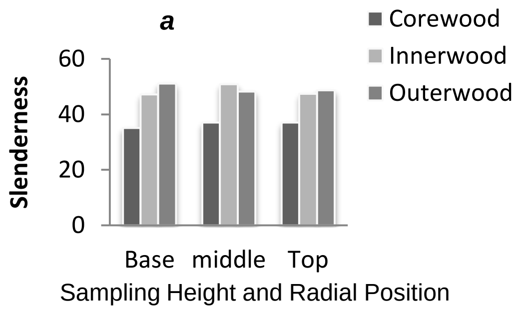

Fig. 4.a
Variation of derived morphology (Slenderness) values along the SH and RP.

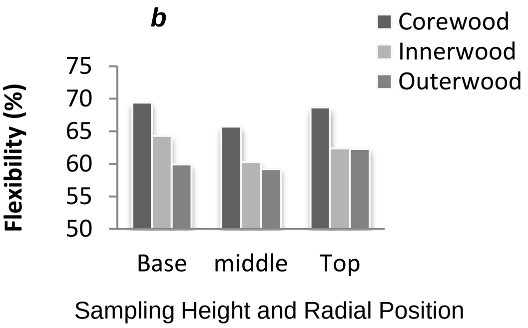

Fig. 4.b
Variation of derived morphology (Flexibility) values along SH and RP.

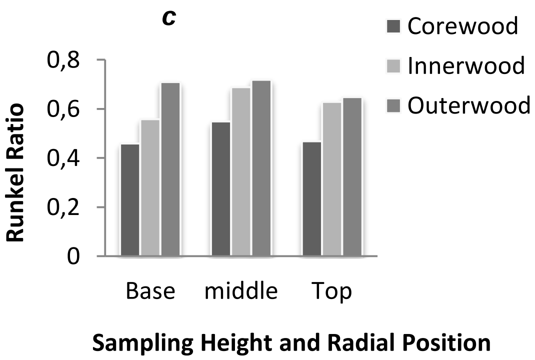

Fig. 4.c
Variation of derived morphology (Runkel ratio) values along the SH and RP.

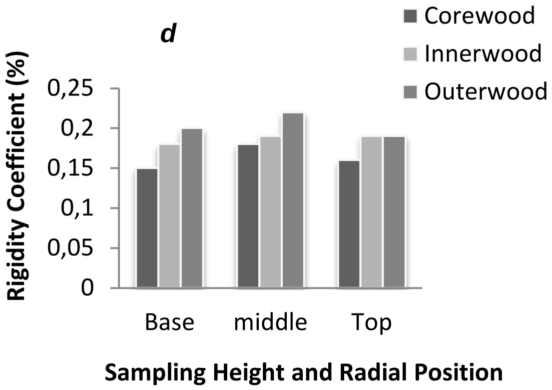

Fig. 4.d
Variation of derived morphology (RC) values along the SH and RP.

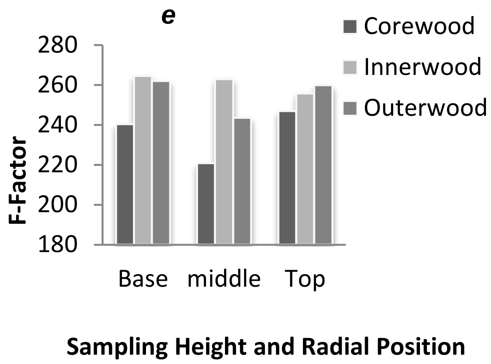

Fig. 4.e
Variation of derived morphology (F-factor) values along the SH and RP.

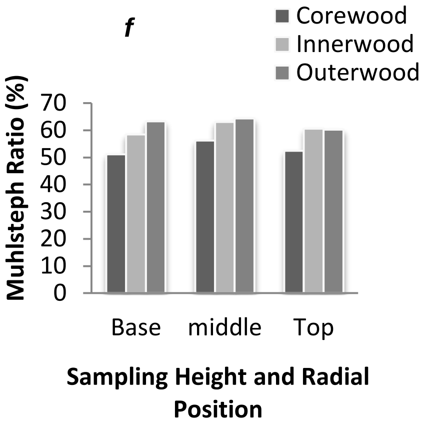

Fig. 4.f
Variation of derived morphology (Muhlsteph ratio) values along the SH and RP.

CONCLUSION

This investigation presented an effort to make known of *Artocarpus altilis* wood as a lesser known wood species by providing detail information about the basic density and fibre properties along the axial and radial portion. The results revealed that the basic density of the *Artocarpus altilis* varies uniformly along the sampling height across the radial position. This implies that quality wood can be obtained within the region of base and middle of the merchantable height. However, *A. altilis* wood can be regarded as a medium density making it suitable materials for light construction while the fibre dimensions of *Artocarpus altilis* are in the normal range for tropical hardwood timbers and the derived morphology indices are found to be reasonably good. These values are of an acceptable range for hardwoods for papermaking.

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