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PROPERTIES OF *MANILKARA DISCOLOR* (SOND.) HEMSL.): A LESSER–KNOWN TIMBER SPECIES FROM KILINDI DISTRICT TANZANIA

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ABSTRACT

This work was conducted to determine some physical and mechanical properties of *Manilkara discolor*, a lesser-known and lesser-utilized timber species from Kilindi District Tanzania. Three large trees free from visible defects were selected, felled and small sample pieces of 20 mm x 20 mm x 60 mm for compression, 20 mm x 20 mm x 20 mm for shear, 20 mm x 20 mm x 45 mm for cleavage and 20 mm x 20 mm x 300 mm for static bending, comprising 72 pieces for each test were prepared. The sample pieces were tested in laboratory using standard methods. The wood was brownish and attractive, fine textured with appealing figure and attaining good finish when plained. The results showed the species to have wood basic Density of 765 kg m^{-3}, Modulus of Elasticity of 14,341 N mm^{-2}, Modulus of Rupture of 119.48 Nmm^{-2}, Work to Maximum Load of 0.132 mm Nmm^{-2} and Work to Total Fracture of 0.284 mm Nmm^{-2}. The Compression parallel to grain was 41.69 Nmm^{-2}, Shear parallel to grain was 18.65 Nmm^{-2} and Cleavage Strength was 34.97 Nmm^{-2}. *Manilkara discolor* wood was found to have desirable values and can be used to substitute other species which are currently in danger of over-exploitation.

Key words: Basic density – Tanga - *Khaya anthotheca - Pterocarpus angolensis*

INTRODUCTION

Wood is among the valuable products obtained from the forest, which when used appropriately, has a very high value since it can be used in many forms for a long time. Wood is therefore, more likely to gain than lose importance in the spectrum of materials in the years ahead (Schniewind, 1979). Since wood is of biological origin, neither are two pieces exactly alike, which lead to differences in appearance and properties.

Bryce (1967) pointed out that the major factors influencing the utilization of wood depends much on its tree dimension, form and quality, workability, physical and mechanical properties, susceptibility to decay and its availability. Many of the uses to which wood is put require the ability to resist loads and that it is recommended to examine the behavior of wood subjected to forces Schniewind (1979). Ishengoma and Nagoda (1991) found out that, although experience and availability have often dictated which species of timber should be used for a particular purpose, a much more detailed knowledge of the properties of timber is required for efficient utilization for exploitation of lesser known species and to aid in selection of species for afforestation. Inadequate information on wood properties specifically of lesser-known timber species is one of the major draw back to their promotion (Lockyer, 1994).

Most indigenous timber species of Tanzania are not yet tested and are not much utilized. Tanzania with about 700 indigenous woody species and of which only a few well-known tree species (about 20) are utilized commercially often for purposes for which other lesser-known but equally suitable and cheaper timber species could be used (Ishengoma *et al*., 1997). This makes a few well known species to be over-exploited while other unknown valuable tree species are left in the forests as the wastes. The unknown tree species are termed as lesser-known species and *Manilkara discolor* is one of these species. Among the better-known timber species include *Khaya anthotheca, Olea welwitschii, Afzelia quanzensis, Dalbergia melanoxylon, Pterocarpus angolensis, Ocotea usambarensis, Milicia excelsa, Belschmedia kweo, Adina microcephala, Afromorsia angolensis* and *Podocarpus usambarensis*, *Cephalosphera usambarensis*, *Juniperus procera, Milletia stuhlmanii, and Brachyleana hutchinsii*

M. discolor a lesser-known species belonging to the family Sapotaceae. It is distributed in East Africa, Eastern and South-Eastern Africa (Centre for Ecology Law and Policy, 2001). The species is also known by such other names as Mgama (Zigua) and Forest milkberry (English).

This research aimed at determination of some physical and mechanical properties of *M. discolor* that would contribute to better and rational utilization of wood resources. The overall objective was therefore, to provide information on the physical and mechanical properties *of M. discolor* wood. Specifically, the following were assessed: physical properties of *M. discolor* to determine tree dimension, form, quality, wood appearance, wood basic density and mechanical properties to determine static bending properties including modulus of elasticity (MOE), modulus of rupture (MOR), and work to maximum load, compression parallel to grain, tangential shearing stress and cleavage stress

MATERIALS AND METHODS

Study site

The sample materials were collected from general land bordering Kilindi Catchment Forest Reserve in Tanga Region. The forest is located between latitude $5^{0}33^{'}$ - $5^{0}40^{'}$ S and longitude $37^{0}33^{'}$ - $37^{0}36^{'}$ E and altitudinal range of between 760 and 1,520 m above sea level. The soil is mainly black sand loam rich in humus on gneissic basement rocks with extensive rock outcrops. The area is characterized by oceanic rainfall of between 1,000 and 1,500 mm year^{-1} and oceanic temperatures, a maximum of 24^{0}C in February and minimum of 19^{0}C in July.

The vegetation type associated with *Manilkara discolor* are the evergreen riverine forest with *Albizia versicolor, Antiaris toxicaria, Diospyros* sp., *Grewia* sp., *Milicia excelsa* and lowland rain forest with *Newtonia buchananii, Entandrophragma excelsum, Parkia filicoidea, Allablackia stuhlmannii* and *Cylicomorpha parviflora.*

Sampling and data collection

Using distractive sampling method, three sample trees were selected purposively in the forest. The criteria for selection based on trees of good form, minimum branches and free from visible defects. Each tree was cut into three logs each representing the butt, middle, and the top, and each log was numbered 11, 12, 13, (for tree 1), 21, 22, 23, (for tree 2) and 31, 32 and 33 (for tree 3). According to Lavers (1969), each log was sawn to cants of about 80 - 100 mm thickness. The cants were further re-sawn to planks from pith outwards in both directions. The planks were numbered sequentially to show the position of extraction. The planks were air dried to about 12% moisture content and were then re-sawn and planed down to 20mm x 20mm sticks/scantlings. It is from these sticks where 72 small sample pieces for each test were extracted. (Table 1).

Table 1 Test sample dimensions and count used for strength properties determination for *Manilkara discolor* from Kilindi District, Tanzania

Type of Test	Sample dimensions (mm)	Sample count
Static bending	20 x 20 x 300	72
Shear parallel to the grain	20 x 20 x 20	72
Cleavage	20 x 20 x 45	72
Compression parallel to grain	20 x20 x 60	72

The strength properties were tested under standard methods stated in BS 373 (1957); ISO 3131 (1975); Lavers (1969) and Ishengoma and Nagoda (1991). The strength values of samples with moisture content lower or more than 12% were corrected to 12% according to standard methods described by Desch (1981).

RESULTS AND DISCUSSION

Physical Properties

Tree dimension, form and quality

Manilkara discolor is a small to medium tree growing to a height of 30 m, with a merchantable bole size of 15 m. The stem is straight and has diameter at breast height (Dbh) exceeding 30 cm. These qualities are better than some of those of the better-utilized timber species. Chudnoff (1984) reported *Pterocarpus angolensis* to have 3 to 7 m of straight bole though Dbh may range from 45 to 75 cm. Ball (2004) observed that *Dalbergia melanoxylon*.rarely exceed 10 m in total height and 38 cm in Dbh, For *Afzelia quanzensis*, the total tree height seldom reaches 24 m (Burgess and Clarke, 2000).

Wood appearance

During the study period, the heartwood of Manilkara discolor was brownish and attractive, comparable to those of *Pterocarpus angolensis, Afzelia quanzensis* and *Khaya anthotheca.* According to Tsoumis (1968), colour is also an indicator of wood's natural durability against decay as it is influenced by the presence of extraneous materials deposited mainly in heartwoods. It was however, not established whether changes in colour with time take place. Nevertheless, as noted by the same author, the natural coloration can be preserved with transparent finishes.

The timber is fine textured with appealing figure of distinctive early and latewood, a characteristic of ring porous species. In addition to this, *M. discolor* timber attains good finish when planed

Wood basic density

The average basic density of *Manilkara discolor* is 765 kgm^{-3} which is higher than that of *Pterocarpus angolensis* and *Milicia excelsa* (657 kgm^{-3} and 620 kgm^{-3} respectively), indicating that the wood can be used as other heavy woods. According to Panshin and De Zeew (1970), woods with density 360 kgm^{-3} or less are considered light, 360 – 500 kgm^{-3} moderate, and above 500 kgm^{-3} heavy. Desch (1973) noted that different timber species, however vary in weight from about 160 - 1,250 kgm^{-3} which is caused by differences in the ratio of cell wall to the air space. The density of wood is of practical interest since is the best indicator of its strength. The uses of *Manilkara discolor* when its density is considered, can be related to that reported by Jan *et al*., (1994) of *Afzelia africana* with basic density of 725kg m^{-3}.

Within a tree, the density of *Manilkara discolor* wood was found to be gradually decreasing from pith outwards to bark from 798 to 760 kgm^{-3} (Figure 1). This trend confirms *Manilkara discolor* a ring porous hardwood as it was noted by Desch (1973), at any given height in the trunk of these hardwoods, there is usually a decrease in density from the pith to the outside of the tree. In diffuse-porous woods, from the pith to the outside of the trunk, there is at first a slight increase and then gradual decrease in density.

In axial direction (Figure 2), the density of *Manilkara discolor* wood increased from butt (744 kgm^{-3}) to the middle of the tree (753 kgm^{-3}) then decreased towards the tip (749 kgm^{-3}).

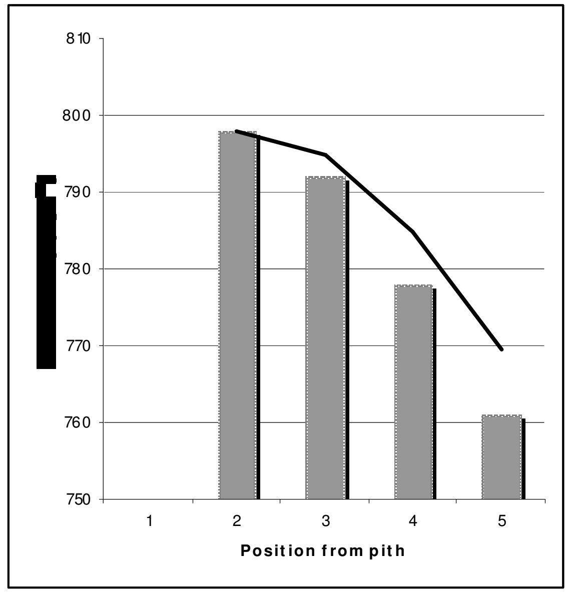

Figure 1: Variation of basic density Variation in basic density of *Manilkara discolor* within a tree in radial direction

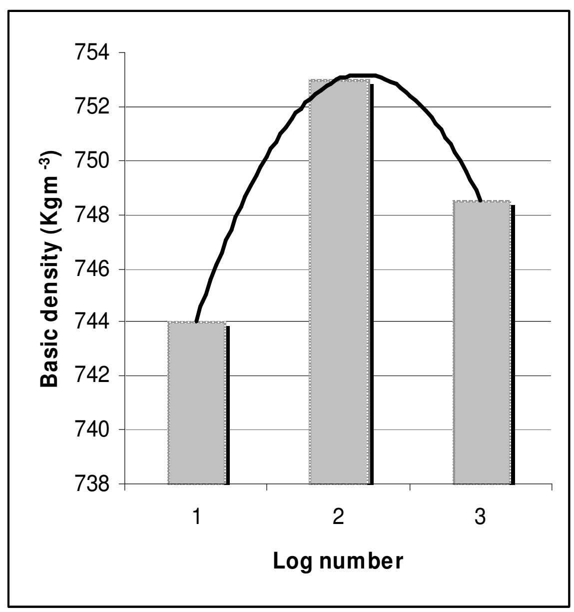

Figure 2: Variation of basic density of *Manilkara discolor* within a within a tree in axial direction

Mechanical Properties

Static Bending

Modulus of Elasticity

Manilkara discolor timber has MOE of 14,340.95 Nmm^{-2} which is high as George (1991) reported that MOE for timber varies between 2,500 and 17,000 Nmm^{-2}. *M. discolor* is superior to both *Pterocarpus angolensis* and *Milicia excelsa* in MOE. Also, other studies on MOE show that *Tectona grandis* (Teak) has 13,720 Nmm^{-2} (Bhat and Priya, 2004), *Afzelia africana* (Afzelia) has 15,000 Nmm^{-2} (Jan *et al.*, 1994) and *Nauclea trillessii* (Opepe) has 13,820 Nmm^{-2} (CIRAD, 2003). These tree species are used for veneer, plywood, poles, mine timbers, joinery, toys, paneling and carvings. within tree MOE variations are presented in Figure 3 and 4 for radial and axial directions.

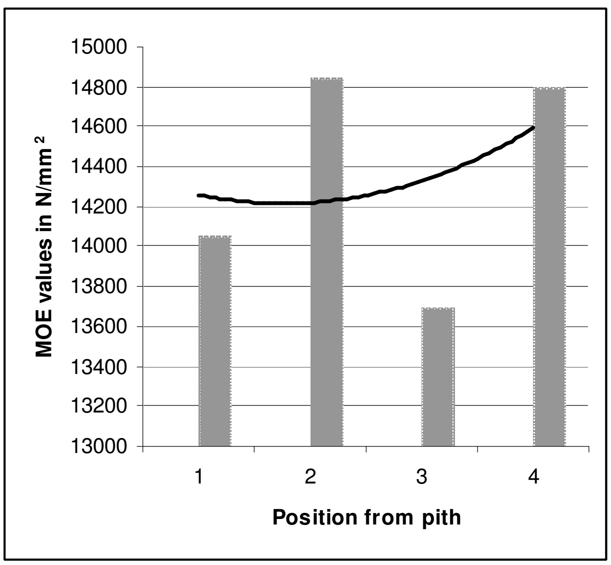

Figure 3 Variation of MOE of Manilkara *discolor* within a tree in radial direction

Though in the radial direction the variation is erratic, in axial direction the stiffest wood is at the middle and the most flexible portion is the one towards the tip.

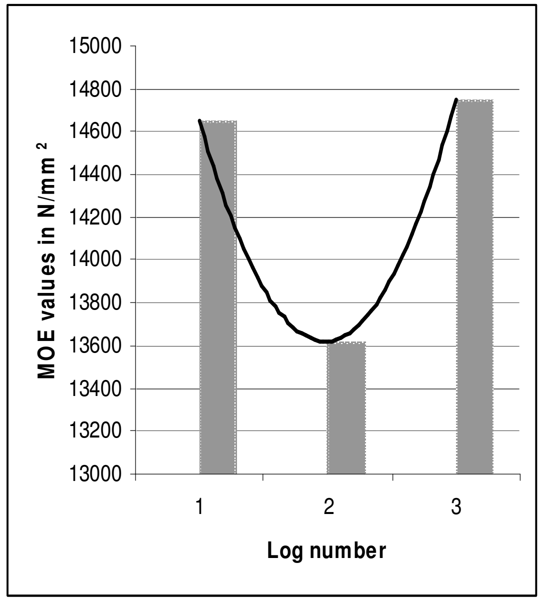

Figure 4 Variation of MOE of *Manilkara discolor* within a tree in axial direction

Modulus of Rupture

Results show that *Manilkara discolor* timber has MOR of 119.48 Nmm^{-2} being higher than *Pterocarpus angolensis* (94 Nmm^{-2}) and *Milicia excelsa* (111 Nmm^{-2}), slightly comparable to *Afzelia africana* (122 Nmm^{-2}). These woods are used in veneers and wood-based boards, furniture, railroad ties, poles, turnery, wagons, mine timbers, flooring, structural work and marine constructions (George, 1991). The variations in MOR for both directions within a tree of *Manilkara discolor* followed the same patterns as those for basic density.

Work to Maximum Load

Results show that work to maximum load of *Manilkara discolor* is 0.132 $mmNmm^{-2}$ being comparable to *Afzelia quanzensis* with

0.131 mmNmm^{-2} and greater than that of *Pterocarpus angolensis* (0.093 mmNmm^{-2}).

Figure 5 and 6 show within tree radial and axial variations of Work to maximum load respectively. Both patterns are more or less similar to those of basic density.

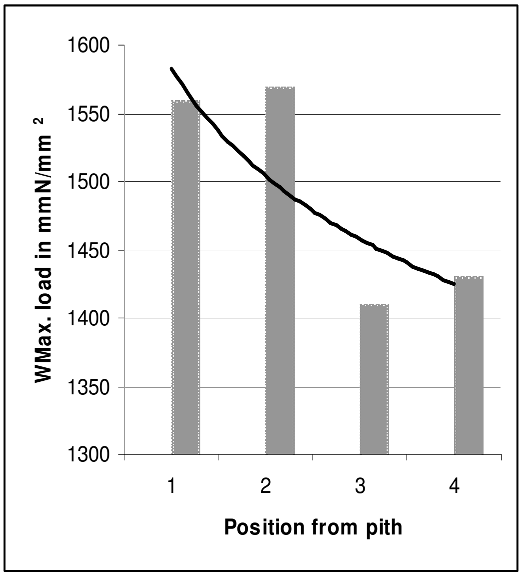

Figure 5 Variation of Work to maximum load of *Manilkara discolor* in radial direction

Compression Parallel to Grain

Manilkara discolor can withstand maximum compressive stress of 41.6 Nmm^{-2} which is almost comparable to those of *Triplochiton scleroxylon* (39 Nmm^{-2}) and Antiaris (*Antiaris welwitschii* 41 Nmm^{-2}). *Manilkara discolor* has lower resistance in compression parallel to grain when compared with *Tectona grandis* with 65 Nmm^{-2} and *Afzelia africana* with 67 Nmm^{-2}. Within tree variation of compression strength from pith to bark shows a rise from the first few growth rings from 4.2 to 4.32 Nmm^{-2} and henceforth, a steady fall from 4.2 to the minimum of 3.99 Nmm^{-2} around the bark (Figure 7). As depicted in Figure 8, in the axial direction, compression strength decreases steadily from 4.33 Nmm^{-2} (the butt), 4.2 Nmm^{-2} (the middle) to 4.0 Nmm^{-2} (the tip).

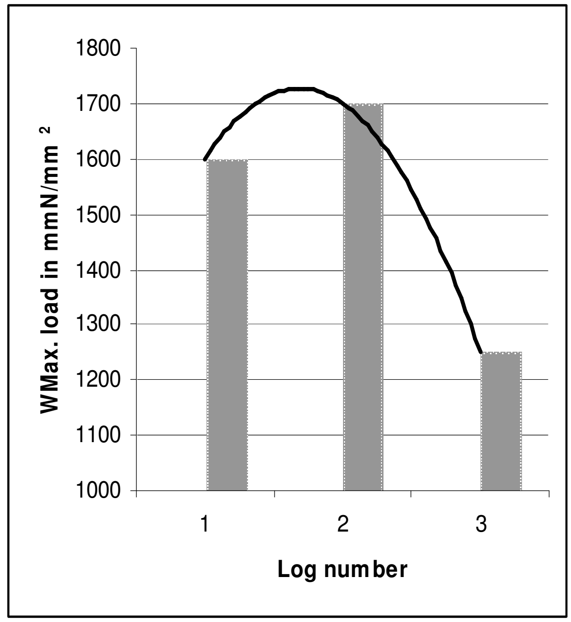

Figure 6 Variation of Work to maximum load of *Manilkara discolor*in axial direction

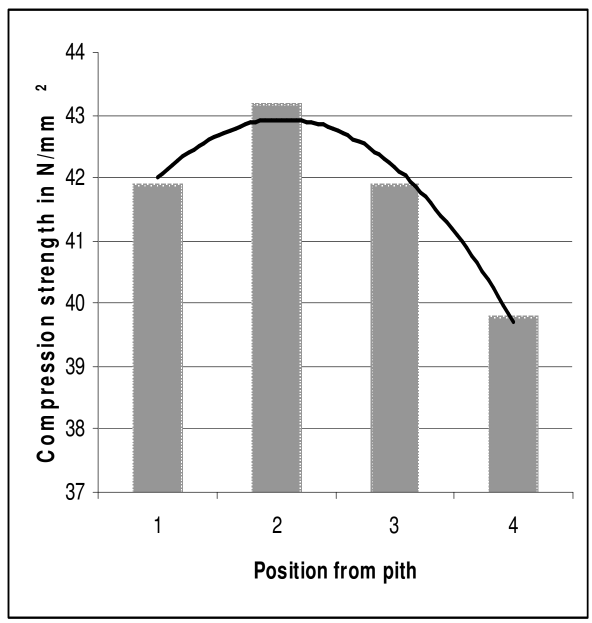

Figure 7Variation of compression strength of *Manilkara discolor* in radial direction

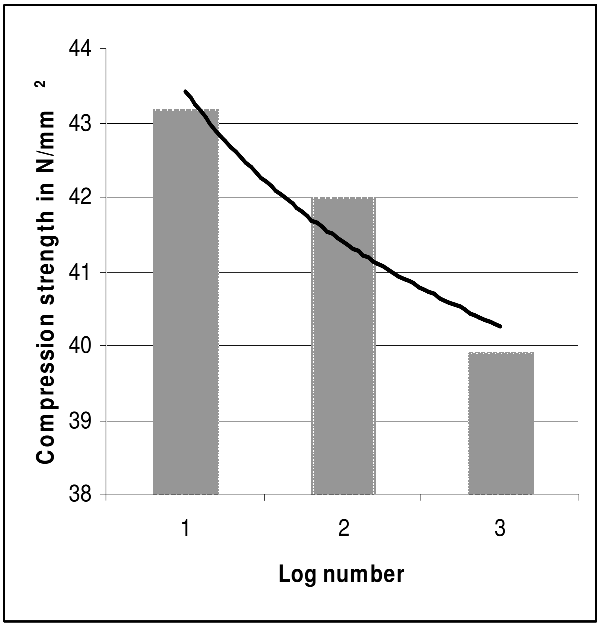

Figure 8 Variation of compression strength of *Manilkara discolor* in axial direction

Shear

Manilkara discolor has an average shear strength of 18.65 Nmm^{-2} which is equal to that of *Morus mesozygia* (Difou), over twice as much as that of *Tectona grandis* (8.8 Nmm^{-2}) and lower than that of *Afzelia africana (*15.9 Nmm^{-2}) and *Heritiera utilis* (Niangon) (15.7 Nmm^{-2}). *Morus mesozygia* is used in building constructions, flooring, furniture, veneer, paneling, joinery, turnery and toys.

Manilkara discolor shows a gradual decrease of shear strength from pith towards bark. There are higher values of shear strength at the butt and a gradual decrease at the middle of the tree to the tip.

Cleavage

The cleavage strength of *Manilkara discolor* is 34.97 Nmm^{-2} which is higher than those of some lesser-known timber species from Tanzania reported by Ishengoma *et al.* (2004) of *Diospyrus mespiliformis* (21.0 Nmm^{-2}), *Newtonia paucijuga* (26.82 Nmm^{-2}) and *Tyrachylobium verrulosum* (20.8 Nmm^{-2}). *Manilkara discolor* has high resistance to cleavage. Whereas in the radial direction cleavage strength decreases from pith to bark, in the axial direction, the trend is opposite.

Correlation between wood density and mechanical properties

Results from this study confirm that basic density influences other wood properties positively and significantly ($p \leq 0.05$) except for cleavage and compression whose influence is insignificant (Table 2). The strength properties can be predicted from wood density using the equations given. As John and Jim (1982) noted, most mechanical properties of wood are closely correlated to wood density.

Table 2 The influence of basic density to strength properties of *Manilkara discolor*

Parameter	Regression equation	R^2	p-value
MOE	$Y = 23{,}100.54 + 11.23\chi$	0.061	<0.01**
MOR	$Y = -145.87 + 0.34\ \chi$	0.620	<0.01**
Work to max. load	$Y = -0.43 + 0.00073\chi$	0.471	<0.01**
Total work	$Y = -0.687 + 0.00123\chi$	0.301	<0.01**
Cleavage strength	$Y = 16.24 + 0.024\chi$	0.085	0.121
Compression strength	$Y = 0.018 + 0.053\chi$	0.258	0.998
Shear strength	$Y = 10.126 + 0.011\chi$	0.094	0.030*

** Statistically significant at $p \leq 0.01$, * Statistically significant at $p \leq 0.05$

Summary

Manilkara discolor tree dimension, form and quality make the species suitable for commercial timber extraction. The wood has good appearance, high basic density and most From the results obtained, Manilkara discolor timber is suitable for furniture, veneer, joinery, panelling and carvings. Other uses are in light constructions, marine construction and floorings.

of its strength properties, which can be compared with those of better known species. Table 3 shows some of the tested mechanical properties of *Manilkara discolor* compared with those of better known species of *Pterocarpus angolensis* and *Milicia excelsa*.

Table 3 Some physical and mechanical properties of *Manilkara discolor*, *Pterocarpus angolensis* and *Milicia excelsa*

Property	*Manilkara discolor*	*Pterocarpus angolensis**	*Milicia excelsa**
Basic density, kgm^{-3}	765.37 ± 28.98	657	620
MOE, Nmm^{-2}	14,340.95 ±	8,443	11,270
MOR, Nmm^{-2}	5,415.6	94	111
Work to max load, $mmNmm^{-2}$	9	0.093	-
Work to total fracture, $mmNmm^{-2}$	119.48 ± 74.36	-	-
Cleavage strength, Nmm^{-2}	0.132 ± 0.04	12.7	-
Compression strength, Nmm^{-2}	0.284 ± 0.10	57	68
Shear strength, Nmm^{-2}	34.97 ± 10.66	17.2	10.8
	41.69 ± 12.41		
	18.65 ± 32.34		

Source: Bryce (1967)

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Manilkara discolor timber is brownish in colour, being as attractive as *Khaya anthotheca*, *Afzelia quanzensis* and *Pterocarpus angolensis.* Due to their colour, the latter species are mostly preferred in many uses which require good appearance.

The timber of *Manilkara discolor* is heavy and its strength properties are generally better than those of *Milicia excelsa* and *Pterocarpus angolensis* the better known and over-exploited timber species from Tanzania.

Within *Manilkara discolor* tree, it can be concluded that the most dense wood is around the pith in the middle section of the stem and lightest is near the bark near the butt end of the first log. Conversely, the strength properties follow this trend positively, except for Modulus of Elasticity which is the reverse.

Recommendations

Manilkara discolor can be used to substitute *Milicia excelsa* and *Pterocarpus angolensis* and also *Khaya anthotheca,* both structurally and by appearance. More lesser-known and lesser-utilized timber species need to be researched to provide a wide range of species for timber utilization. Under proper management, these timbers can be harvested for sustainable utilization so as to reduce poverty as well as conserve the forests by diversifying the timber harvestable species.

In order to gain knowledge of the full potentials of *Manilkara discolor*, it is recommended that other researchers take a look at such other properties of this species as anatomical, chemical and natural durability.

For applications where strength is a pre-requisite, the middle section of the stem should be considered and the wood near the butt end avoided.

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