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# Anatomical, Physical and Mechanical Properties of five Wood Species growing in North Darfur.

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**Abstract**

Anatomical, physical and mechanical properties were determined for five species growing in North Darfur. All anatomical properties were determined from macerated fibers. The fiber length was determined using stereological techniques on macerated fiber. The other anatomical characteristics measured included fiber length (FL), fiber diameter (FD), fiber lumen (FLD), double cell wall thickness (DCWT), rankles ratio (RR), coefficient of cell rigidity (CR), and fiber flexibility (FF). These other anatomical characteristics were measured by an electronic image analyzer in Giad Material Research Laboratory. The physical properties tested comprised density, moisture content and shrinkage. Static bending was also carried out for determining modulus of rupture (MOR) and modulus of elasticity (MOE). This, in addition to compression parallel to the grain (COM). All physical and mechanical properties were carried out according to standard procedures. The results of the analysis of variance revealed significant differences in most of the anatomical properties between species. Fiber length ranged between 2.28mm for kafour and 1.45mm for haraz. Fiber diameter, on the other hand ranged between16.75µm for sunt and 14.11 µm for haraz. Fiber lumen diameter was highest for haraz (7.832µm) and lowest for talh (6.122µm).Double call wall thickness, on the other hand, ranged between 8.95µm for sunt to 6.22µm for hraz. Runkle ratio,however, was highest for talh(1.834) and lowest for haraz (0.842).For coefficient of cell rigidity talh was highest (0.288), while haraz was the lowest (0.223). Fiber Flexibility ranged between 0.55 for haraz to 0.433 for Kafour. Modulus of Rupture ranged between 139.70 MPa for sunt and 68.74 MPa for haraz. Compression parallel to the grain, on the other hand, ranged between 68.41 MPa for sunt and 35.86 MPa for haraz. Modulus of elasticity from bending ranged from 12873.6 MPa for sunt and 6507 MPa for haraz, while modulus of elasticity from compression was highest for talh (2413.5 MPa) and lowest for haraz (1000.8 MPa).Density ranged from 0.95g/cm3 for sunt and 0.50g/cm3 for hraz. Shrinkage, however, showed no significance variation between the species.

2 Nor Eldin Adam Abdallah Mohammed/ International Journal of Research Publications (IJRP.ORG)



Key Words: Anatomical Properties; Physical Properties; Mechanical Properties; Relationship.

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**Introduction**

Virtually all wood properties are affected by its anatomical structure. Wood is a raw material of variable structure, suitable for thousands of uses . Wood properties vary between and within species as well as between different parts of the same tree. Research on wood has proved that the climatic conditions of the area in which the species grow has a significant effect on the properties of the wood (Roqu, 2004; Alevs and Angyalossy-Alfonso 2000; Wimmer, 2002; Desch and Dinwoodie, 1996).

Ideally, the extent of this wide differences needs to be fully investigated. In many cases, more than one property of wood is important to the end use. Knowing and understanding the properties of any material is the key to its development and rational utilization. Efficient utilization means that species should be matched to end- use requirements through an understanding of their properties (Simpson and Tenwolde, 1999).

The anatomical, physical and mechanical characteristics of wood are considered the fundamental basis for timber use. Studies of wood properties have a special significance in promoting quality research in wood products. Although it is necessary to have an in-depth knowledge of wood properties, it is necessary for the engineer to have a general understanding of the properties and characteristics that affect the strength and performance of wood in construction. This includes not only the anatomical, physical, and mechanical properties of wood as a material, but also the standards and practices related to the manufacture of structural wood products, such as sawn lumber, glued laminated wood and plywood.

Density varies greatly depending on the anatomical structure of the wood. Tsoumis (1991) pointed out that density is the best and simplest index of the strength of clear wood; with increasing density, strength also increases. This is because density is a measure of the amount of cell wall materials contained in a given volume of wood. Therefore, higher density denotes larger amount of cell wall available to resist external forces. It serves as a measure for the mechanical properties such as bending and represents the simplest and the best indicator of wood quality (Kubler, 1980). When wood material is able to resist extreme external load without deformation in the shape, this wood material can be classified as stiff material and in all cases wood elasticity is measured by modulus elasticity (MOE) while the wood resistance against failure is measured by modulus of rupture (MOR) (Rammer 2010; Kretschmann 2010).

Wood is highly anisotropic in its strength properties i.e. it has different property values in longitudinal and lateral directions. This is due to its cellular structure and the physical organization of the cellulose chain molecules within the cell walls (Schniewind, 1989). The good mechanical behaviour (strength) of wood expresses the efficiency and ability of wood to resist external loads that change its dimensions and shape. Green *et al*. (1999) stated that, mechanical properties are commonly measured and presented as “strength properties” for design including modulus of rupture in bending, maximum stress in compression parallel to the grain, compressive stress perpendicular to the grain, and shear strength parallel to grain.Hardness is a measure of the resistance of wood to the entrance of foreign bodies in its mass (Tsoumis, 1991).

This study aimed at carrying out quantitative analysis of the anatomical structure of five wood species, growing in Northern Darfur, using stereological techniques. This, in addition to determining some physical and mechanical properties of the selected species, for establishing relationships between the two groups of properties in the second paper,

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## Material and Methods

### Material

The wood species used in this investigation included the following:

| | |
|---|---|
| *1-Balanites aegyptiaca* | Heglig |
| *2-Eucalyptus camaldulensis* | Kafour |
| *3-Acacia nilotica* | Sunt |
| *4-Acacia seyal* | Talh |
| *5-Faidherbia Albida* | Haraz |

### Methods

### Sampling

Three trees were selected randomly for each species. The sample trees were collected from different areas of North Darfur the three trees of *Acacia Nilotica* (Sunt) were collected randomly from Dawa Forest, while the three trees of *Acacia seysl* talh were collected from Tarma Forest. However, trees of *Blanites aegyptica* and *Faidherbia albida* were selected from Fattabarno Forest. The distances between selected trees in each forest were more than 100 meters. The tree height and diameter at breast height were measured using a caliber and sunto clinometers, as shown in table 1. Logs 1.5 meters long were cut from the base of each tree for the purpose of this investigation. These logs were sawn into boards and random sample were taken from these boards for preparing test specimens for deterring the different properties.

### Anatomical structure

The anatomical investigations were conducted in Forest Research Centre (FRC) at Soba and Material Research Centre (GIAD). The determination of anatomical properties was based on macerated fibres. The maceration procedure developed by Shultze as cited in Jane (1970) was used to liberate the fibres from each other. To do this wood chips from each species were boiled in concentrated nitric acid (60%) in a water bath for 10 minutes. Liberated fibres were washed several times to remove relics of nitric acid and then left for about 10 minutes in distilled water. When the fibers settled down, excess water was gently drained away, the macerated material was placed in Petri dishes, stained by few drops of safranin dye for ten minutes and then rewashed using a series of alcohol concentrations (50%, 70%, and 95%) and water.

The prepared macerated materials were placed on glass slides with one drop of Canada Balsom on the slide. Each slide was then covered gently with a cover slip measuring 2.2x2.2 cm.The prepared slides were left to dry gradually for three days after which they were ready for examination and determing the different fibre characteristics.

### Fiber length determination

Stereological technique was used for determining the fiber length. To do this the macerated fibers were projected from the stage of a projecting microscope through a digital camera onto a computer screen with a square grid 20x20cm with seven equidistant horizontal parallel lines. Then stereological counts for determine the fibers length were carried out. These counts included the number of points of intersections with fiber boundaries per unit line ($P_L$) and the number of fibers per unit area ($N_A$). The magnification used was108x.

These stereological parameters were used to calculated fiber length from the following equation:

$FL= \pi P_L/2N_A$………………………………………………. (1)

This part of the investigation was conducted at the Forest products division at the Forest Research Center (Soba).

**Cross-sectional measurements**

The transverse measurements of fibers included, fiber diameter, fiber lumen diameter and double cell wall thickness. All of these properties were measured using an electronic projecting microscope (model: kross) using 10x magnification. This part of the study was carried out at the Material Research Center (GIADs). The measurements obtained from this machine were fiber diameter (FD) and fiber lumen diameter (LD). From these two parameters the double cell wall thickness was calculated from the following equation:

DCWT = FD - LD…………………………….(2)

Where:-

DCWT= Double cell wall thickness (µm)

FD= fiber diameter (µm)

LD = Fiber lumen diameter (µm).

Using the three above parameters the following ratios were calculated. Coefficient of Cell Rigidity (CR), Rankle Ratio (RR) Fiber Flexibility(FF) from the following formulae:

CR= DCWT /FD ………………………………………….(3)

Where:

CR=Cell Rigidity

RR= DCWT/LD……………………………………………(4)

Where:-

RR= Rankle Ratio

FF= LD/ FD…………………………………………(5)

Where:-

FF= Fiber Flexibility

**Volume fractions of cells and their components**

Four temporary cross-sectional slides were prepared from randomly selected samples from each species using sliding microtome. The section were stained by soaking them in safranin for five minutes and washed by alcohol and water. The sections were mounted on glass slides using Canada Balsam as temporary slides. The slides were allowed to dry and examined under microscope for cell type's proportions and their components using stereological techniques. The techniques involved projecting the image of the slides from a microscope stage through a camera on to a computer screen with square grid imposed on the projected image. The grid was 10×10cms with four equidistant horizontal lines criss-crossing four vertical lines resulting in 16 intersection points representing the total test points. A point count was made for components of cell types: vessel wall, vessel lumen, fiber wall, fiber lumen, and parenchyma wall and parenchyma lumen. The point count represented the number of test points falling on a feature divided by the total test points (Pp). From the proportion of cell components the proportion of cell types (vessel, fibers, and parenchyma) was worked out, in addition to the proportions of total cell walls and total cell lumens.

**3.3.3. Physical properties**

**3.3.3.1. Density**

The wood density was determined using Sudanese Standard 1512-2:2015: *Wood – determination of density for physical and mechanical tests.* Density was determined at equilibrium moisture content (7%).

**Shrinkage**

The wood Shrinkage was determined using Sudanese Standard 1748:2013 *Wood – determination of radial and tangential shrinkage.* Shrinkage was determined between 30- 0% moisture content.

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**Mechanical properties**

The wood for mechanical properties determinations was air dry at equilibrium moistre content (7%). The tests were carried out according to Standard procedures.

**Static bending**

Static bending was determined according to the Sudanese Standard 5176: 2012. *Wood – determination of ultimate strength in static bending.* The size of the test specimens was 2cm×2cm×30mm. They were at equilibrium moisture content (7%). The machine used for static bending test was the Universal Testing Machine (Model WDW -100). The Modulus of rupture (MOR) and Modulus of Elasticity (MOE). Were calculated as follows:

$MOR = 3PL/2bd^2$ …………………………… (6)

L = length of span (mm)

b = width of specimen (mm)

d = depth of specimen (mm)

$MOE = P*L^3/4\ bd^2$ ………Δ……………….. (7)

Where:

P*=´ is the load, in N, at the limit of proportionality.

L =is length of span, in mm.

Δ =´ is the deflection, in mm at the limit of proportionality.

**Compression parallel to the grain**

Compression strength parallel to the grain, on the other hand, was carried out in accordance to ISO Standard 3787 – 1976 *Wood – determination of ultimate stress of compression parallel to the grain.* using universal testing machine (model WDW-100). Specimens were at equilibrium moisture content (7%).

**Statistical Analysis**

In this study SAS procedures were used to investigate the variation in anatomical, physical and mechanical properties. Analysis of variance and Duncan's Multiple Range Test (DMRT) were conducted looking for significant differences in all studied properties between the species and separating the means.

**Results and Discussion**

**Anatomical properties**

Table 1 shows the anatomical properties (Fiber dimensions and ratios) of the five studied species. They included the Fiber Length (FLmm), Fiber Diameter (FDµm), Fiber Lumen Diameter (FLDµm) Double Cell Wall Thickness (DCWTµm), Rankle Ratio (RR),Coefficient of Cell Rigidity (CCR) and Fiber flexibility (FF). Analysis of variance showed significant differences in all properties between species.

**Table 1. anatomical characteristics of the five species studied**

| **Species** | **FLmm** | **FDµm** | **FLD µm** | **DCWT µm** | **RR** | **CR** | **FF** |
|---|---|---|---|---|---|---|---|
| *Acacia nilotica* | 2.10A | 16.75A | 7.80A | 8.95 A | 1.16A | 0.27A | 0.46B |
| *Acacia seyal* | 1.45B | 14.967B | 6.122B | 8.377A | 1.834A | 0.288A | 0.442B |
| *Eucalyptus camaldolensis* | 2.28A | 14.499B | 6.167B | 8.004A | 1.334A | 0.285A | 0.433B |
| *Blanites aegyptiaca* | 1.77B | 14.167B | 6.870A | 8.098A | 1.269A | 0.272A | 0.457B |
| *Faidheribia albida* | 1.58B | 14.113B | 7.832A | 6.284B | 0.842B | 0.223B | 0.55A |

Means with same the letter are not significantly different at 0.05
* Where:
FL= Fiber length, FD= Fiber Diameter, FLD = Fiber lumen diameter, RR= Rankles Ratio, DCWT= double cell wall thickness, CR= Coefficient of cell Rigidity, FF= Fiber Flexibility.

**Fiber length**

The analysis of variance showed that there was significant variations in fiber length among species (p =0.0002). The results of Duncans Multiple Range Test (DMRT) are shown in table 1. The results revealed that *Eucalyptus camaldolensis* had the highest mean value (2.28mm), followed by *Acacia nilotica* (2.10mm), without a significant difference between them but with significant differences from all other species. These were followed by *Blanites aegyptiaca*(1.77mm), *Faidheribia albida (1.58* and .lastly *Acacia seyal* which had the shortest fiber length value among the five species(1.45B) without any significant difference between the three but with significant differences from kafour and sunt. These results were in agreement with those reported by Nasroun and Alshahrani (1998); Yosif (2001); Osman (2000).Who reported significant variations among species in fiber length. However, the mean fiber length values of *Eucalyptus camaldolensis* were slightly lower than what was found by Nasroun and Alshahrani (1998).

**Fiber Diameter**

The results of analysis of variance for fiber diameter revealed that there were significance variations in fiber diameter among the five species (p=0.0226). The highest mean value (16.75um) of fiber diameter was recoded for *Acacia nilotica* with significance differences from all other species, this was followed by *Acacia seyal* (14.97*um*), *Blanites aegyptiaca(*14.67*um*), *Eucalyptus camaldulensis* (14.499) and the lowest value was found in *Faidherbia albida(14.17um)* without significant difference from each other, but with significance

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difference from sunt. Hence the results were close to those found by Nasroun and Alshahrani (1998); Gamal (2007).

**Fiber Lumen Diameter**

Variations in Fiber lumen diameter were significant between the five species (p=0.0195). *Acacia seyal* had the highest mean value(7.80*um*) Followed by *Faidheribia albida(7.83um)*,*Blanites aegyptiaca* (6.87*um*)without any significant difference between the three species, but with significant difference from all other species .These were followed by *Eucalyptus camaldulensis*(6.17*um*), *Acacia seyal* (6.12*um*) both of which had significantly lower FLD than the first three species but without any significant differences between them. These results were not far from those found by Nasroun and Alsharani (1998).

**Double Cell Wall Thickness**

Variations in the values of double cell wall thickness among species were highly significant (P= 0.0002). The highest mean values (8.95*um*) of double cell wall thickness were recorded for *Acacia nilotica*, followed by *Acacia seyal* (8.38*um*),Blanites aegyptiaca (8.098*um*), *Eucalyptus camaldulensis* (8.00*um*) respectively without significant differences between them, but with significant difference from haraz, which had the lowest mean value(6.28*um*). The results were close to those found by Nasroun and Alsharani (1998).

**Rankle Ratio**

Analysis of variance showed highly significant variation (P=0.0026) in Rankle ratio among the five species. Table1 shows that with regards to rankle ratio *Acacia seyal* had the highest mean value (1.83), this was followed by *Eucalyptus camaldulensis* (1.33), *Blanites aegyptiaca* (1.27) and *Acacia nilotica* (1.16) without any significant difference between them, but all of them were significantly different from haraz (0.84). The results were slightly lower than those found by Nasroun and Alsharani (1998).

**Coefficient of Cell Rigidity**

Based on analysis of variance there were highly significant variations in coefficient of cell rigidity between the five species (P= 0.0006). Table 1 shows that *Acacia seyal* had the highest value(0.29), followed by *Eucalyptus camaldulensis (0.29)*,*Blanites gyptiaca* (0.27) and *Acacia nilotica* (0.27), without any significant difference between them but all with significant difference from haraz (0.22) which had the lowest value with significant difference from all other species. The results were also close to those found by Nasroun and Alshahrani (1998).

**Fiber Flexibility**

The analysis of variance indicates highly significant variation in Fiber Flexibility among species (P= 0.0014). With regards to Fiber flexibility (FF).*Faidherbia albida* had highest value (0.55A) with significant difference from all other species. Followed by *Acacia nilotica* (0.46), *Blanites aegyptiaca* (0.46), *Acacia seyal* (0.44), *and Eucalyptus camaldulensis* (0.43), without any significant difference between them but with significant difference from *Faidherbia albida.* These results were also close to those found by Nasroun and Alshahrani (1998).

DCWT, RR and CR showed the same trend with regards to the order of the species, while FF showed the opposite trend. That is, the species with the lowest value with regards to the first three parameters (haraz), had the highest value in FF and vice versa.

**Volume fractions for cell types and their components**

Table 2 shows the volume fractions of the different cell types and their components. With regard to point fraction for vessel ($P_PV$) the highest value was found for *Blanites aegyptica* with significant differences from other species. This was followed by *Acacia seyal, Eucalyptus camaldulensis* and *Acacia nilotica* without any significant difference between the three of them while *Faidherbia albida* had the lowest value with significant difference from all other species.

With the regard to volume fraction for fiber ($P_PF$) highest value was found in *Acacia nilotoca* Followed by *Acacia seyal*, *Eucalyptus camaldulensis* without the significant difference between them. These were followed by *Faidherbia albida*, and *Acacia nilotica* without any significant between the three them or Acacia albida and *Blanites aegyptica* which had the lowest value with significant difference from *Acacia nilotica*,

*Acacia seyal and Eucalyptus camaldulensis* but with significant different with *Acacia albida*.
With regard to volume fraction for Parenchyma ($P_PP$) the highest value was found in *Faidherbia albida* with significant difference from other species. This was followed by *Eucalyptus camaldulensis,Blanites aegyptica, acacia seyal and Acacia nilotica* without any significant difference between them, but with significant different with *Faidherbia albida.*

**Table 2. Volume fraction for different cell types and their components for different species.**

| Species | $P_PV$ | $P_PF$ | $P_PP$ | $P_PCW$ | PpCL |
|---|---|---|---|---|---|
| *Blanites aegyptica* | 0.25 A | 0.48 C | 0.22 B | 0.54 B | 0.46 A |
| *Acacia seyal* | 0.14 B | 0.64 AB | 0.21 B | 0.61 AB | 0.39 A |
| *Ecalyptus camal-* | 0.14 B | 0.60AB | 0.28 B | 0.52 B | 0.47 A |
| *Acacia nilotica* | 0.12 B | 0.70A | 0.16 B | 0.68 A | 0.26 B |
| *Faidherbia albida* | 0.03 C | 0.56 BC | 0.40 A | 0.54 B | 0.46 A |

Means with the same letter are not significantly different at 0.05.

PpV = volume fraction of vessels, PpF = volume fraction of fibers, PpP = volume fraction of parenchyma, PpCW= volume fraction of total cell wall, PpCL= volume fraction of total cell lumen.
For volume fraction for total cell wall ($P_PCW$) the highest value was found in *Acacia nilotica*, followed by *Acacia seyal* without any significant difference between them, but with significant difference with haraz, heglig amd kafour. The highest value for the volume fraction for total cell lumen (PpCL) was for kafour (0.47) followed haraz, heglig and talh, without any significant difference between them, while sunt had the lowest value (0.26) with significant difference from all other species. Woody cells, like any plant cells are composed of cell wall and cell lumens. This is why the volume fraction of total cell walls and volume fraction of total cell lumens add up to 1.0 or close to 1.0.

**Physical characteristics**

**Density**

Table 3 shows the investigated physical properties for the five species. It indicates that there were highly significant variations in Density among the species (P<0.0001).

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**Table 3. Physical characteristics of the five species**

| Scientific Name | Common Name | Density g/ $cm^3$ | Shrinkage% | | |
|---|---|---|---|---|---|
| | | | Tangential | Radial | Longitudinal |
| *Blanites aegyptiaca* | Heglig | 0.78 B | 11.53 A | 5.62 A | 1.59 A |
| *Eucalyptus camaldulensis* | Kafour | 0.58 C | 12.22 A | 6.26 A | 1.19 A |
| *Acacia nilotica* | Sunt | 0.95 A | 11.62 A | 5.28 A | 0.86 A |
| *Acacai seyal* | Talh | 0.92 A | 11.77 A | 5.32 A | 1.09 A |
| *Faidherbia albida* | Haraz | 0.50 D | 11.13 A | 5.22 A | 1. 33 A |

Means with same letter are not significantly different at 0.05.

The results of Duncan's Multiple Range Test (DMRT) in table 3 revealed that the highest Density value recorded was for sunt (0.95 g/$cm^3$), followed by talh (0.92 g/$cm^3$) with no significant difference between them, but with significant difference from all other species. These were followed by heglig (0.78g/$cm^3$),with significance difference from all other species. Then Kafour (0.58 g/$cm^3$), with significance difference from all other species, and lastly haraz (0.50g/$cm^3$), which had the lowest value with significant difference from all other species. Densities for haraz and kafour were close to what was obtained by Nasroun (2005) while the other three species were slightly higher.The density of wood is of practical interest because it is the best single criterion of strength. Some strength properties like compression parallel to the grain, bending strength and hardness are already known to show a very strong correlation with density (Desch and Dinwoodie, 1996). Species with high density such as sunt(0.95g/cm3), talh (0.92g/cm3),and heglige(0.78g/cm3) are expected to have high strength values and recommended for such end uses as heavy constructions, as railway sleepers, flooring and other load-bearing structures. Kafour (0.57g/cm3), and Haraz (0.50g/cm3), associated with moderately heavy density values.

**Shrinkage**

According to analysis of variance test no significant differences were observed in shrinkage (Tangential, Radial or longitudinal) values between the wood species (table 3). However, there were some insignificant differences between the species the highest value for tangential shrinkage was associated with *Eucalyptus camaldulensis (12.22%)*, followed by *Acacia seyal* (11.77%) *Acacia nilotica (11.62%), Balanites aegyptiaca (11.53%)*, *faidherbia albida (11.35%)*, while the lowest shrinkage value was found *in haraz* (11.13%). In radial shrinkage the results revealed that *faidherbia albida* had the highest value in radial shrinkage (5.56%), followed by *kafour* (5.45), *Sunt* (5.33%),and heglige (5.30055%). Lastly Taleh (5.2105%). The results also revealed that Sunt had highest value in longitudinal shrinkage(0.8874%), hraz (0.7845%), kafour (0.5763%), heglig (0.52726%). Lastly talh (0.4432%). The results are not in agreement with the result of Ameer (2001) who reported significant differences between the tree species he studied. The values obtained in this investigation were also higher than those obtained by Nasroun (2005).

**Mechanical properties**

The Anova test showed that the variation between species in Modulus of Rapture (MOR) was very significant (P <0.0001). Compression parallel to the grain (COM) also showed highly significant variation between species (P <0.0001). Modulus of elasticity (MOE) from bending showed the same trend - highly significant differences between species ( P<0.0001), and so was modulus of elasticity from compression (MOC).

**Static Bending**

Modulus of Rupture

Table 4 shows the separation of means of mechanical properties. The table revealed that *Acacia nilotica (Sunt)* had the highest value in modulus of rupture, with significant differences from all other species (139.70).This was followed by *Acacia Seyal (*125.31*),* with. significant difference from all other species. While *Blanites aegyptiaca (*107.13*),* and *Eucalyptus camadulensis (*99.03*),* had close value with no significant difference between them but with significant difference from all other species,. Lastly *Faidherbia albida* had the lowest value (68.74) with significant difference from all other species.

**Table 4. Mean values for mechanical properties (MPa) of the five species**

| Species | MOR | COM | MOE | MOC |
|---|---|---|---|---|
| *Acacia Nilotica* | 139.70 A | 68.46 A | 12873.6A | 2166.3AB |
| *Acacia Seyal* | 125.31 B | 65.65 A | 11092.0B | 2413.5A |
| *Eucalyptus camadulensis* | 99.03 C | 57.00 B | 8503.4C | 1727.5C |
| *Blanites Eagyptiaca* | 107.13 C | 47.47 C | 8813.4C | 1959.7BC |
| *Faidherbia albida* | 68.74 D | 35.86D | 6507.8D | 1000.8D |

Means with same letter are not significantly different at point 0.05.
* Where:
MOR= Modulus of Rupture, COM= Compression parallel to the grain
MOE= Modulus of Elasticity. MOC = MOE from compression

**Modulus of elasticity from bending**

With regards to Modulus of Elasticity (MOE) the results showed that *Acacia nilotica* had the highest value(12873),with significant difference from all other species (table 4). This wasfollowed by *acacica seyal(11091),* also with significant difference from all other species. *Blanites Eagyptiaca(8813), and Eucalyptus camadulensis(8503.4),* followed without any significant difference between them but significantly different from other species. Lastly *Faidherbia albida(6507.8)* had the lowest value with significant difference from all other species.

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**Compression Parallel to the grain**

The analysis of variance indicated highly significant variations in Compression Parallel to the grain between species (P< 0.0001). Table 4 also shows the separation of means for Compression Parallel to the grain. The table showed that *Acacia nilotica* had the highest value (68.47) followed by *Acacia Seyal(*65.65*)*without any significant difference between them, but with significant differences from all other species. These were followed by *Eucalyptus camadulensis*(57.00) with significant variation from all other species. Followed by *Blanites Eagyptiaca (*47.47*)*, with significant from all others species. Lastly *Faidherbia albida*had gave the lowest value (35.86*)*with significant difference from all other species.

**Modulus of elasticity from compression**

With regards to modulus of elasticity for compression (MOC) the analysis revealed that *Acacica seyal(2413.5 MPa)* and *Acacia nilotica(2166.3)*had the highest values, without any significant difference between them but with significant differences from all other species (table 4). These were followed by *Blanites Eagyptiaca(1959.7 MPa), and Eucalyptus camadulensis(1727.5)* without significant difference between them but with significant difference from other species. Lastly *Faidherbia albida* had the lowest value(1000.8 MPa)with significant difference from all other species.

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