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Anatomical, Physical, Mechanical and Technological Properties of Four Secondary, Lesser-Used Wood Species Growing in Blue Nile State, Sudan

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Abstract

This investigation aimed at determining basic wood properties and quality attributes for four wood species growing in Blue Nile State as indicators for the different uses. The basic properties determined included some anatomical fiber characteristics, Most of these properties were determined from macerated fibers. Cell and cell components proportions, however, were measured from cross-sections, prepared by the microtome. These proportions and the fiber length were estimated using stereological techniques. . Physical properties - density, permeability, tangential shrinkage, radial shrinkage and moisture content, in addition to glue bond strength were determined according to standard procedures and so was compression parallel to the grain. Texture and surface quality, however, were determined according to an arbitrary visual grading method. Analysis of variance and Duncan's Multiple Range test were carried out, looking for the levels of significance of the variations in all properties. Anatomical properties showed significant differences between the four species. . Physical properties also showed significant differences between the species studies. Talh had the highest density (0.82g/cm³) while Tartar had the lowest density (0.38g/cm³). Tangential and radial shrinkage were highest in gughan (10.19%), (5.41%) and lowest in Talh (6.02%), (3.06%) respectively. Liquid absorption (AB) ranged between Tartar (207.94%) and Talh (57.85%). Most of the absorption in tartar was along the grain and very little across the grain. Compression parallel to the grain showed a significant difference between talh, goghan 210,70MPa and kakamut (838.94, 840 and 838 MPa, respectively) on one side and tartar (210,70MPa) on the other; tartar being the weakest. Glue bond strength (BS) ranged between gughan (27.141Mpa) and Tartar (0.751Mpa), indicating that only gughan and kakamut gave adequate bond strength. With regards to texture gughan had the finest texture and grain uniformity, followed by kakamut and talh while tartar had a moderately course texture. Both kakamut and talh were also figured.

Keywords: Wood structure, Basic properties, Talh, Goghan, Kakamut Tartar.

Introduction

Wood is a product of a complex biological system, the tree, and as such it is a highly variable material. This variability is due, mainly, to variations in anatomical structure. Its anatomical structure and other properties vary from species to species, from tree to tree of the same species, and even from one part of a single tree to the other. Thus utility of a piece of wood for a specific application is dependent upon its properties which, in turn, are influenced by structure (Ifju,1982; Nasroun, 2005; Forest Products laboratory, 2010). Wood properties can be subdivided into two groups: microscopic and macroscopic. Microscopic properties are linked to the anatomical structure of wood as well as its chemical composition, while macroscopic properties are primarily growth-related features and include knots, compression wood and spiral grain (Megraw, 1986).The anatomical structure on the molecular and cellular levels affect almost all wood properties. The macroscopic features are often used as the basis for visual grading of wood products, particularly sawn timber. Macroscopically, wood can be described as an orthotropic or anisotropic material with three main directions: longitudinal direction (L), while radial (R) and the tangential (T) directions in the transverse plane. The mechanical properties of wood in the radial direction slightly higher than in the tangential direction, and both radial and tangential properties are about one order of magnitude lower than the properties in the longitudinal direction (Mishnaevsky and Qing , 2008).

Density (or specific gravity) is one of the most important physical properties of wood (Desch and Dinwoodie 1996)(Bowyer *et al* 2003). Density is directly related to other properties and therefore is important as an index of wood quality (de Zeeuw, 1965). Perhaps the single most important property controlling the mechanical performance of a piece of wood is its density. A good understanding of a material and its properties is a key to its development and rational use. The objective of this study is, therefore, to start a long term program for determining anatomical, physical, mechanical and technological properties for the secondary hardwood species which dominate Sudan forests and use them as indicator for end-uses, starting with the four specie under investigation.

Materials and Methods

Materials

Four of the lesser used wood species which are available in reasonable numbers in Blue Nile State and other parts of Sudan were selected for this investigation. The selected species comprised:
Sterculia setigra (tartar), *Acacia polyacantha subsp. Campylacantha* (kakamut), *Acacia seyal* var. *seyal* and *Diospyros mespiliformis* (goghan) .

Methods

Sampling

Sampling of test material was carried out according to the Sudanese standard 5172: 2012, *Wood- sampling methods and general requirement for physical and mechanical testing of small clear wood specimens.*

Testing for different properties

Compression parallel to the grain was carried out in accordance to ISO 3787: 1976 standard: *Wood- Determination of Ultimate Stress of Compression Parallel to the Grain.* The test was carried out using Universal testing machine. The test specimens were at equilibrium moisture content (7%).

Shrinkage

Both of tangential and radial shrinkage were determined according to Sudanese standard 1748: 2013, *Wood – determination of radial and tangential shrinkage*. Shrinkage values taken from fiber saturation point (30%) to oven dry condition (0% moisture content). Values of longitudinal shrinkage were not estimated because they are usually very slight.

Density

Wood density was determined according to the Sudanese standard 5174: 2012, *Wood – determination of density for physical and mechanical tests*. The density was determined for air dry samples at equilibrium moisture content (7%).

Permeability

Ten samples measuring 50×50×20 mm were selected randomly from sapwood of the different species at 7% moisture content. The weight of the samples was recorded before soaking in test solution using fuchsin acid dissolved in water giving a dark red color to facilitate measurement of liquid penetration .Then the test solution containing the test samples was heated in a water bath for two hours; after that the solution and the samples were allowed to cool down over night. The test specimens were weighed again to determine the absorption percent and measure the depth of lateral penetration.

Anatomical Properties,

Most of anatomical properties were based on macerated wood materials. Chips were taken from the four species and macerated to isolate the fibers. The wood chips were macerated by heating them in 60% nitric acid. The cook was allowed to heat in a water bath for ten minutes the acid was removed and the fibers washed by water several times. Then the macerated fibers were stained by safranin for five minutes and then the fibers were washed first by alcohol followed by water several times. The stained fibers were mounted on four glass slides for each species using Canada Balsam. The prepared slides were left to dry before microscopic examination for measuring the following anatomical parameters.

Fiber length determination

To determine the fiber length the stereological technique was used. The slides were projected from the microscope stage through a camera onto a computer screen with a square grid (2oX20cm) fixed on the screen. The grid consisted of seven equidistant parallel lines each measuring 20 cm. The stereological counts made included points of intersection of test lines with the fiber boundaries per unit test line (P_L) and the number of fibers per unit area (N_A). From these two parameters the fiber length was calculated using the following equation:

Fiber length = $\Pi \; P_L / 2N_A$……………………………………… …..(1)

3.2.4.2. Cross-sectional dimensions and ratios

The same slides prepared for macerated fibers were used for determining fiber diameter (FD), lumen diameter (LD) and double cell wall thickness (DCWT). These basic anatomical properties were measured by using an electronic reflecting microscope (Olympus Instructions GX71 Inverted System Metallurgical Microscope) at Giad's Material Research Center. Using the above mentioned parameters three important ratios were calculated. These included, rankle ratio (RR), Coefficient of fiber rigidity (CR) and fiber flexibility (FF) from the following equations:

RR = DCWT/LD ……………………………………………… ………..(2)

CR = DCWT/FD ……………………………………………… ……… (3).

FF = LD / FD………………………………………… …………….. (4)

Volume fractions of cell types and their components

Temporary cross-sectional slides were prepared from randomly selected samples from each species using the sliding microtome. The sections were stained by soaking them in safranin , washed and mounted on glass slides as mentioned above. The proportions of cell types (vessels, fibers and parenchyma) and their components (cell walls and cell lumens) were determined using stereological techniques.

Technological Properties

Gluing properties

Ten specimens were tested for their adhesion strength according to Sudanese standard 1339: 2015, *Adhesives - Wood-to-wood- Determination of shear strength by compressive strength*. The adhesive used was an ordinary thermoplastic resin commonly used in furniture industry.

3.2.5.2.Texture;

Ten clear samples measuring 20×20×60 mm each were randomly selected from samples prepared for compression test. The samples were visually evaluated for their texture, grain uniformity and smoothness. The evaluation was based on arbitrary numerical values given to each specimen based on the quality of the above mentioned parameters. The numerical values varied in the range 1- 10; ten being the finest texture and the best surface quality while one represented the roughest surface. The specimens used were clear specimens – without any defect to confine the evaluation on textural features and touch smoothness of the wood surface.

3.2.6. Statistical Analysis

Analysis of variance was carried out followed by Duncan's Multiple Range Test (D M R T) for significant differences in all properties studied and mean separation. Correlation analysis was also carried out to find relationships between wood basic properties (anatomical and density) and wood quality attributes for the different uses like wood strength, dimensional stability, permeability, gluability and appearance.

Results and Discussion

Anatomical Properties

Fiber length

ANOVA results showed very significant differences between species in fiber length (P<0.0001). Table (1) shows the means separations for fiber characteristic

Where; *Sterculia setigera*(1.75)had the highest mean value of fiber length with significant difference from all other species. Followed by *Acacia seyal* var. seyal (1.59) and then *Diospyros mespiliformis* (1.52) without significant difference between the two. *Acacia polyacantha* had a significantly lower mean value of fiber length. The mean fiber length values of tartar are slightly lower than those reported by (Gamal, 2007) while that of talh and goghan are higher. Also the mean fiber length values of talh are greater than those obtained by (Nasroun, 1978)

Cross sectional parameter

The analysis of variance results indicated that there were highly significant variations in fiber diameter between the species studied (P< 0.0001). Table 2 shows that *Acacia polyacanatha* had the highest mean value of fiber diameter of the studied species (20.85 um) with significant difference from all other species, followed by *Diospyros mespiliformis* (15.05) and then *Sterculia setigera* (14.34) without significant variation between them .Lastly *Acacia seyal* var. seyal (12.94) without significant difference from *Sterculia setigera* and with significant difference from *Acacia polyacanatha* and *Diospyros mespiliformis.* The obtained mean fiber diameter values of tartar, talh and goghan were lower than those reported by (Gamal, 2007) also the mean fiber diameter of talh is lower than that reported by (Nasroun, 1978).

In the lumen diameter ANOVA analysis showed highly significant differences between the four species (P< 0.0001). The highest mean value of lumen diameter of the four species was recorded by *Acacia polyacanatha* (14.02 um) with significantly different from others followed by *Diospyros mespiliformis*(7.81) and *Sterculia setigera*(7.74) without significant difference between the two but with significant difference from others. Talh (4.97) had the lowest value of lumen diameter with significant variations form all other species studied. The mean fiber lumen diameter for talh was slightly lower than that obtained by (Nasroun, 1978) (Gamal, 2007) While the mean fiber lumen value of goghan and tartar were also lower than those reported by (Gamal, 2007).

ANOVA showed moderately significant difference in double cell wall thickness (DCWT) between species studied (P = 0.0451), Where *Acacia seyal* (7.94 um) had the highest mean value of DCWT with significant variation from *Acacia polyacantha* and *Sterculia setigera* while *Diospyros mespiliformis*(7.25) was not significantly different from all species followed by *Acacia polyacantha* (6.85) and *Sterculia setigera* (6.60) without significantly different between the two and with significantly different from *Acacia seyal*. The mean DCWT values of talh, goghan and tartar were lower than those reported by (Gamal, 2007) also the mean for talh was slightly lower than that obtained by Nasroun (1978).

Analysis of variance results showed highly significant differences in runkle ratio (RR) between the four species (P < 0.0001). The highest mean value of runkle ratio was recorded for talh (1.75) with significant difference from all species followed by goghan(0.98) and then tartar (0.90) without significant variation between the two. Kakamut (0.52) had the lowest mean value of RR and was significantly different from all species. The mean RR of talh was greater than those reported by (Gamal, 2007) (Nasroun, 1978) while the mean R R for goghan and tartar were less than those obtained by (Gamal, 2007).

The analysis of variance results also indicated that there were highly significant differences in coefficient of fiber rigidity (CR) between species (P < 0.0001). The results given in table 2 show that talh (0.31) had significantly the highest mean value of CR followed by goghan (0.24) and tartar (0.23) without significantly different from each other. Lastly kakamut (0.17) had the lowest mean value of CR with significant difference from all others. The mean C R of talh was higher than that reported by (Nasroun, 1978)

Anova test for fiber flexibility (FF) showed highly significant differences between the four species (P < 0.0001); where kakamut (0.67) had the highest mean value of FF with significant variation from other species followed by tartar (0.54) and goghan (0.52) without significant difference between the two; the lowest mean value of FF was recorded for talh (0.39) with significant difference from all other species. The mean FF of talh was lower than that obtained by (Nasroun, 1978)

Table 1. The mean values of fiber characteristic for the four species.

Spp	Dimensions				Ratios		
	FL(mm)	FD(μm)	LD(μm)	DCWT(μm)	RR	CR	FF
Di	1.52B	15.05 B	7.81B	7.25AB	0.98B	0.24B	0.52B
PO	1.35 C	20.85 A	14.02A	6.85B	0.52C	0.17C	0.67A
Se	1.59 B	12.94 C	4.97C	7.94A	1.75A	0.31A	0.39C
St	1.75 A	14.34 BC	7.74B	6.60B	0.90B	0.23B	0.54B

FL= Fiber length, FD = Fiber diameter, LD = Lumen diameter, DCWT =Double cell wall thickness, RR = runkle ratio, CR = coefficient of
Rigidity, FF = Fiber flexibility, Spp = Species, Di = *Diospyros mespiliformis** PO= *Acacia polyacantha** Se = *Acacia seyal var. seyal** St = *Sterculia setigera*

Volume fractions of cell types and their components

ANOVA results showed no significant difference in volume fraction of vessels (Pp v) between the species studied, but Pp V was highest in goghan (0.08) and kakamut (0.08)followed by tartar (0.07) lastly talh (0.05) without significant differences between all species studied. Table (3) shows the results of DMRT for volume fractions of cell types and their components. In volume fraction of fiber(Pp F) ANOVA results showed very significant variation between species studied (P< 0.0001). G goghan(0.81) had the highest mean value in Pp F with significant difference from all other species. Followed by kakamut (0.62), talh (0.54) and tartar (0.34) with significant differences between all of them. Analysis of variance showed highly significant differences between the four species in volume fraction of parenchyma (Pp P) (P < 0.0001). Based on DMRT tartar (0.59) was significantly the highest mean value followed by talh (0.42), kakamut (0.30) came next and lastly goghan (0.10) with significant difference between all species studied.

Also the analysis of variance showed highly significant variation in volume fraction of cells wall (Ppcw) between the four species (P < 0.0001). Table 2 shows the results of Duncan Multiple Range Test. The highest mean value in Ppcw was recorded by goghan (0.70) with significant difference from others followed by kakamut (0.62) with significant difference from all species studied, followed by tartar (0.52) and talh (0.51) without significant difference between the two but with significant difference from other species. In volume fraction of cells lumen (Ppcl) ANOVA results showed highly significant difference between the species studied (P< 0.0001). Where talh (0.50) had the highest mean value in Ppcl followed by tartar (0.48) without significant difference between the two and with significant difference from the remaining species studied. Kakamut (0.39)came next with significant variation from all species studied. Lastly goghan (0.31) with significantly different from the species studied. The results concerning Pp cw and Pp cl are rather odd because of the fact that talh with the highest density should have the highest Pp cw and the lowest Pp cl. This discrepancy was due to the poor quality of the sections prepared for this purpose because the only available microtome was in a bad condition.

The analysis of variance showed significant difference in volume fraction of fiber lumen (Pp FL) between the four species (P = 0.0015). Tartar (0.18) had the highest mean value in Pp FL with significant difference from all other species. Followed by kakamut (0.13), talh (0.10) and goghan (0.09) without significant variation from each other. The highest proportion of Pp FL is reflected in density where tartar has the lowest density among the four species studies.

Table(2)The mean values of volume fractions for cell types and their components

Spp	Pp V	Pp F	Pp P	Ppcw	Pp cl	Pp FL
Di	0.08A	0.81A	0.10D	0.70A	0.31C	0.09B
Po	0.08A	0.62B	0.30C	0.62B	0.39B	0.13B
Se	0.05A	0.54C	0.42B	0.51C	0.50A	0.10B
St	0.07A	0.34D	0.59A	0.52C	0.48A	0.18A

PpV = Volume fraction of vessels* PpF = volume fraction of fiber* PpP = volume fraction of Parenchyma* Ppcw = Volume fraction of cells wall* Ppcl= Volume fraction of cells lumen* PpFL = Volume fraction of fiber lumen*Spp = Species* Di = Diospyros mespiliformis* PO= Acacia polyacantha* Se = Acacia seyal var. seyal* St = Sterculia setigera.

Physical and Mechanical Properties

Table (3) shows the results of analysis of variance for physical and mechanical properties. The ANOVA results showed highly significant differences in density between the four species ($P<0.0001$). Based on DMRT talh (0.82 g/cm³) had the highest mean value of density with significant variation from the other species This was close to what was obtained by Nasroun (2005) (0.80 g/cm³). This was followed by kakamut (0.74 g/cm^3) and goghan (0.74 g/cm^3) without significant difference from each other but with significant variation form others. Tartar (0.38) had the lowest mean value with significant difference from all species studied.

The analysis of variance also showed highly significant differences in compression parallel to the grain between the four species ($P<0.0001$); where the highest mean value was associated with goghan (840.00 kg/cm^2) which was not significantly different from kakamut (838.94 kg/cm^2) and talh (838.94 kg/cm^2), lastly tartar (210.70 kg/cm^2) had the lowest mean value with significant variation form all other species studied. The value obtained for talh is higher than that obtained by Nasroun (2005). This puts goghan, kakamut and talh in the forth strength group from six strength groups for our local structural timbers as specified by the Sudanese standard 5332 (2012).

The ANOVA results showed very significant differences in tangential shrinkage between the four species ($P<0.0001$). Goghan (10.19%) had the highest mean value with significant difference from others followed by tartar (7.70), kakamut (6.76) and talh (6.02) without significant difference from each other. The analysis of variance also showed very significant differences in radial shrinkage between the species studied ($P< 0.0001$); where goghan (5.41%) had the highest mean value with significant variance from the species studied followed by tartar (4.33%) without a significant difference from kakamut (3.43%) and with significant difference from others. lastly talh (3.06) without significantly different from kakamut but with significant difference from species studied. The shrinkage values obtained for talh were close to these reported by Nasroun (2005).

The analysis of variance also showed highly significant differences in liquid absorption (AB) ($P<0.0001$) and depth of penetration ($P<0.0001$). Based on DMRT tartar (207.94%) had the highest mean value with significant variation from others followed by goghan (82.51%) and kakamut (78.82) without significant difference from each other but with significant difference from others. Talh (57.85%) had the lowest mean value with significant variation from all species studied. This agrees with the fact that talh had the highest density and the highest DCWT in its anatomical structure. Most of the absorption in tartar was along the grain and very little across the grain. In Depth of penetration (PD) goghan (1.94 cm) had the highest mean value with significant variation from others followed by kakamut (1.75 cm) and talh (1.75 cm) without significant difference from each other. Tartar (0.21 cm) had the lowest mean value which was significantly different from all species studied.

Table 3 The means separation for physical and mechanical properties studied

Spp	DEN g/cm³	Com Kg/cm²	Shrinkage (%)		Permeability	
			T	R	AB (%)	PD(cm)
Di	0.74 B	840.00 A	10.19 A	5.41 A	82.510 B	1.9400 A
PO	0.74 B	838.94 A	6.76 B	3.43 BC	78.820B	1.7500 B
Se	0.82 A	838.94 A	6.02 B	3.06 C	57.850 C	1.7500 B
St	0.38 C	210.70 B	7.70 B	4.33 B	207.940 A	0.2100 C

DEN = density* Com = compression parallel to the grain* T = tangential * R = Radial* AB = Absorption* PD = Depth of penetration* Spp = Species* Di = Diospyros mespiliformis* PO= Acacia polyacantha* Se = Acacia seyal var. seyal* St = Sterculia setigera.

Texture

The ANOVA result showed significant differences in wood texture between the four species (P=0.0080). Table (4) shows the means separation values for gulability and texture; where *Diospyros mespiliformis*(8.50) had the highest mean value in texture with significant difference from all other species followed by *Acacia polyacantha* (7.10) and *Acacia seyal*(6.50) without significant difference between the two and lastly *Sterculia setigera* (4.10) with significant difference from all other species. These results show that goghan had the finest texture, grain uniformity as well as surface smoothness .It was followed by kakamut which had a moderately fine texture, the wood was also figured. The same with talh which had moderately fine texture and figured. Tartar, on the other hand, had a moderately course texture but it was also figured.

Glue bond strength

The analysis of variance showed very significant differences in glue bond strength between the four species (P<0.0001); where *Diospyros mespiliformis* resulted in the strongest bond (27.14 MPa) followed by *Acacia Polyacantha* (24.95 MPa) without a significant difference between them but with significant difference with the other two species. *Acacia seyal* came next (3.96 MPa) with significant difference from All species followed by *Sterculia setigera* (0.75 MPa) also with significant difference from others.

Table (4)The mean values of glue bond strength and texture for the four species

Species	Glue bond strength(MPa)	Texture
Di	27.141 A	8.50 A
PO	24.956 A	7.20 A B
Se	3.959 B	6.40 BC
St	0.751 C	5.10 C

Spp = Species* Di = Diospyros mespiliformis* PO= Acacia polyacantha* Se = Acacia seyal var. seyal* St = Sterculia setigera

Conclusion and Recommendation

The properties determined in this study revealed that the four species studied covered a wide spectrum of properties and quality attributes which qualified them for a number of uses.

Similar results are expected for most of the othe**r** secondary species which are not used.

It is, therefore, recommended to continue this kind of research to find uses for as many secondary species as possible as means of rationalizing the utilization of our wood resources and making the harvesting of our natural forest more economical.

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الخصائص التشريحية والفيزيائية والميكانيكية والتكنولوجية لأربعة أنواع من الأخشاب الثانوية قليلة الاسنخدام النامية في ولاية النيل الأزرق– السودان.

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المستخلص

استهدفت هذه الدراسه تحديد خصائص اربعه من انواع الاخشاب الاقل استخداما والناميه فى ولايه النيل الازرق بالسودان للوصول للاستخدامات المناسبه لهذه الانواع. وشملت انواع الاخشاب المدروسه كل من الطلح والجوغان والكاكموت والترتر . شملت الخصائص الاساسيه المدروسه بعض الخصائص التشريحيه والكثافه كما شملت الخواص الداله على نوعيه وجودة الخشب, قوة ومتانة الأخشاب, نفاذيه الاخشاب, معدلات الانكماش المماسى والقطرى, قوة وصلات المواد اللاصقه بالاضافه لنوعيه السطح والقوام. بعض الخصائص التشريحيه اجريت على الياف محرره. وتم تحديد الخصائص ا الفيزيائيه والمكانيكيه والتكنولوجيه والتى تمثل الخواص الداله على جوده الاخشاب باستخدام طرق قياسيه ماعدا القوام ونوعيه السطح والتى تم تحديدها بطريقه تدريج بصرى. وقد اظهرتحليل التباين للخصائص فروقا معنو يه فى معظم الخصائص المدروسه بين الانواع الاربعه من الاخشاب. ففى الخصائص التشريحيه حظى الترترباطول الالياف (1,75مم) وكان الكاكموت اقصرها الياقاً (1,35مم) وتفاوت قطر الالياف بين (20,85ميكرون) للكاكموت و (12,94ميكرون) للطلح وكان لقطر الفراغ الخلوى نفس التوجه. وكان سمك الجدار الخلوى المزدوج اعلاه للطلح (7,94ميكرون) وأدناده فى الترتر (6,60ميكرون) . فى حاله الخصائص الفيزيائيه بلغت الكثافه اعلاها فى الطلح (0,82جم/سم³) وادناها فى الترتر (0,38جم/سم³). وجاء الانكماش المماسى والقطرى اعلاهما فى الجوغان (10,19% و 5,41% على التوالى) واقلهما فى الطلح (6,02% و 3,06% على التوالى). وتفاوتت نسبه امتصاص السائل بين الترتر (207,99%) والطلح (57,85%). بينما كان عمق التغلغل فى الاتجاه العرضى اعلاه فى الجوغان (1,94سم) واقله فى الترتر (0,21سم). وكانت أعلى قيمة لمقاومه الانضغاط الموازى للالياف من نصيب الطلح (840كجم/سم²) والجوغان والكاكموت بدون فرق معنوي بينهم وادناها من نصيب الترتر (210,70كجم/سم²). اما قوة وصلات المواد اللاصقه فقد كانت اعلاها فى الجوغان والكاكموت (27,141ميقاباسكل و24,956ميقاباسكل على التوالى) وادناها فى الترتر والطلح (0,751ميقاباسكل و 3,959ميقاباسكل على التوالى). مما يوحى بان قوة الربط فى الجوغان والكاكموت تعادل مقاومه القص الموازى للالياف فى النوعين اعلاه. وفيما يختص بقوام الاخشاب ونعومه السطح فقد اظهرت النتائج ان الجوغان كان اكثرها نعومه واتساقا للسطح يليه الكاكموت ثم الطلح واخيراً الترتر.