SOME WOOD PROPERTIES OF *MELIAa AZEDARACH* L. TREES GROWN IN DUHOK PROVINCE

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ABSTRACT

***Melia azedarach* L. was introduced into Kurdistan region and planted as an ornamental tree at the nurseries, parks and streets. This study investigated the quality of wood of 9 year old *M. azedarach* trees grown in Duhok province. Samples of wood from five trees were taken at breast height diameter; and their wood quality was studied in terms of morphological, physical and anatomical properties. Results revealed that the values of morphological properties were: the Heartwood percentage (69.01%), Sapwood percentage (12.93%), Bark percentage (8.06%) and Annual Ring Width (7.74mm). While, the values of the physical properties were: specific gravity (0.42), basic density of wood (0.36g/cm^3), annual ring growth width (7.74cm), moisture content (44.46%), maximum moisture content (208.36%), volumetric shrinkage (13.18%), volumetric swelling (16.25%), fiber saturation point (36.34%), cell wall (28.05%) and porosity (71.94%). The values of anatomical properties were: fiber length (0.792 mm), fiber diameter at the mid- point of the fiber (17.75 µm), fiber double cell wall thickness (9.67 µm), fiber lumen width (8.07µm), runkel ratio (1.55), flexibility ratio (47.17), slenderness ratio (47.58), vessel length (241.57µm), vessel diameter at the mid- point of the vessel (169.09µm), and vessel lumen diameter (158.26µm). All properties showed a significant variation from pith to bark and between the trees. The results equip a basis for determining management planning opportune to production wood of *M. azedarach* plantation trees in Kurdistan region. Also *M. azedarach* is characterized by low strength resistance and perhaps low pulping production too, therefore according to its low wood quality for some properties, is not recommended for structural purposes. While anatomical properties, showed medium values of fiber dimensions which could be used for production of special type of paper**

Key words: ***melia azedarach* L., wood properties, wood variation.**

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بعض صفات الخشب لأشجار السبحبح .*Melia Azedarach* L النامية في محافظة دهوك

ئاري عادل عبدالقادر هشيار حازم سليمان ناصر عبدالسلام داؤود
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المستخلص

تم أدخال أشجار السبحبح الى أقليم كوردستان وزرعت كأشجار زينة في المشاجر و الحدائق العامة و الشوارع. تستهدف الدراسة الحالية الى تقويم هذه الأشجار ذات التسعة أعوام و النامية في محافظة دهوك. أختيرت خمسة أشجار لأخذ عينات الخشب عند مستوى أرتفاع الصدر، وقد درست كل من صفات الخشب المورفولوجية، الفيزياوية و التشريحية. و تشير النتائج بأن قيم الصفات المورفولوجية كانت: نسبة الخشب القلبي (69.01%)، نسبة الخشب العصاري (12.93%)، نسبة القلف (8.06%)، و عرض حلقة النمو (7.74 ملم)، في حين الصفات الفيزياوية كانت: الوزن النوعي (0.42)، كثافة الخسب الأساسي 0.365 غم/سم^3)، المحتوى الرطوبي (44.46%)، أعظم محتوى الرطوبي (208.36%)، الأنكماش الحجمي (13.18%)، الأنتفاخ الحجمي (16.25%)، نقطة تشبع الألياف (36.34%)، جدار الخلية (28.05%)، المسامية (71.94%). أما قيم الصفات التشريحية كانت: طول الليفة (0.79 ملم)، عرض الليفة عند الوسط (17.75 مايكرون)، ثخن جداري الخلية (9.67 مايكرون)، عرض تجويف الليفة (8.07 مايكرون)، نسبة الرنكل (1.55)، نسبة المرونة (47.17)، نسبة الأستدقاق (47.58)، طول الأوعية (241.57 مايكرون)، عرض الأوعية عند الوسط (169.08 مايكرون) وعرض تجويف الأوعية (158.26 مايكرون). أظهرت جميع الصفات تباينات معنوية داخل الشجرة من اللب الى الفشرة و بين الأشجار أيضا. كما بينت النتائج الأساس لأيجاد كيفية التخطيط و الأدارة المناسبة لأنتاج الخشب من مشاجر هذه الأشجار في أقليم كوردستان. وعليه و ستنادا ألى أنخفاض نوعية الخشب لبعض صفات السبحبح، لا يوصي أستعماله لأغراض الهيكلية في حين أن الصفات التشريحية أظهرت قيم المتوسطة أبعاد الليفة و التي من الممكن أستخدامها لأنتاج أنواع خاصة من الورق.

الكلمات المفتاحية: أشجار السبحبح، صفات الخشب، تباين الخشب.

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INTRODUCTION

Chinaberry tree (*Melia azedarach* L.) is a fast-growing, deciduous tree of the Meliaceae family, native to the Asian Himalayas (59). This species adapts well to poor soils, warm climates and seasonally dry status (18), widely distributed, dries well and easy to process without cracking or warping (40). A very important tree for local people, therefore it is cultivated in wide area for supply the world demand for wood produces, pulp and paper production (13) as well as supply a wide range of medicinal applications and insecticide (8 and 17). It is often planted as an ornamental and street tree, although it has the disadvantage of dropping a lot of leaf-litter (60). *M. azedarach* wood, of trade, is utilized to manufacture plywood, furniture, poles, boxes, tool handles and agricultural implements (62). Properties of wood vary from tree to tree, across the height, around the radius even inside the growth ring, and are also affected genetically (65 and 51). There are also variations in all wood properties during the transformation from sapwood to heartwood (33 and 52). The proportion of heartwood, sapwood and bark content at DBH and along the stem has a major impact on the end utilizer of the wood products (45 and 39). In addition the heart wood percentage (HWP) assessment aims to determine variations in durability and other wood properties (61, 7, and 55). Wood specific gravity is a gauge of the mass of solid cell walls substance a tree species allocates to strength and mechanical support (20 and 36). Wood density is a primary wood property and an indicator of hardness, strength and easy of drying (44 and 23). Changing in wood moisture content causes the dimensional instability, swelling and shrinkage (4 and 63). The variation in anatomical wood properties has an impact explicitly or implicitly on the productive use of wood for various end uses. Wood fibers and vessels constitute major elements of wood and are expected to relate closely with wood properties (16). Density is influenced by divergences of cell property like the cell length, cell wall thickness, and cell diameter (19 and 24). Reforestation projects need recognize not only the tree growth and survival, but also the quality and utilization potential of the promising tree species, particularly for rapid growth species, when picking tree species for planting projects (28). Since information about wood properties of *M. azedarach* cultivated in Kurdistan region it is rare, consequently, this study was conducted to determine the properties of wood (Morphological, Physical and Anatomical properties), and to evaluate its potential as a raw material to be used for different purpose, in different industries.

MATERIALS AND METHODS

Wood Preparation

The trees of *Melia azedarach* were collected from the stand of College of Agricultural Engineering Sciences, University of Duhok which located in Sumail district. A total of five trees 9 years old were selected randomly based on their quality of stem. Before trees felling, diameter at breast height (DBH) and the height of trees were estimated (Table 1), Stem cross-sectional samples (disk of 5 cm thickness) was taken from each tree at 1.3m above the ground (DBH).

Morphological Properties

Samples of wood discs were observed with the aid of a top-lighting microscope; the heartwood/sapwood boundaries were determined because of their sharp colour and length; the digital Verner used to obtain their length from the total length of the disk without bark and their proportions were measured as an equal geometric circle percent by pure arithmetic calculation. The bark percentage was calculated as the variations between the total area of the disk and the area of disk without bark, while the number of growth rings was counted from pith to cambium according to Moya and Munoz (36) that is indicated in Table 2.

Physical Properties

To study the physical properties, wood disks were split it into 10 specimens at dimensions of 20 × 20 × 30 mm, according to ASTM D-l43-94 standards (5). Fifty specimens were assigned for measured following parameters:

The specific gravity (Sp.gr) and basic density (D_b) were determined according to the method described by Haygreen and Bowyer (20), were determined by using the following equation:

Sp.gr = M_0/V_0. Where the (M_0) is the oven-dry weight of the samples and (V_0) is the dry volume of the samples.

$D_b = M_0 / V_g$ (g /cm^3). M_0 is the oven-dry weight of the samples (g) and Vg is the green volume of the samples (cm^3). Volumetric shrinkage, volumetric swelling, Moisture content and maximum moisture content were determined according to the method described by Akyildiz and Kol (2). Volumetric shrinkage (β_v) was determined by the Following equation:

$\beta_v = (V_s – V_0) / V_s$ (%)

Where V_s is saturated volume and V_0 is oven-dry volume. While, the volumetric swelling (α_v) was determined by the Following equation:

$\alpha_v = (V_s – V_0) / V_0$ (%). (V_s) is saturated volume and V_0 is oven-dry volume.

Moisture content **(MC) = (M_g –M_0) / M_0 (%)**. (M_g) green weight of the wood samples (g) after cutting and (M_0) dry weight of wood samples after dried in oven dried at 105±2 ^{o}C, until a constant weight of wood.

Maximum moisture content MMC= (1.5 – D_b) / (1.5 × D_b) (%)

While fiber saturation point (FSP), percentage of cell wall and porosity were determined by following the method described by Korkut and Guller (26). (**FSP)= β_v / D_b (%)**, where β_v is the volumetric shrinkage (%) and D_b is basic density (g/cm^3).

Anatomical Properties

For evaluation the anatomical properties, the samples of wood were cut to small pieces and prepared for maceration process according to Franklin method (15), that consisted of glacial acetic acid and hydrogen peroxide at 1:1 percentage, the samples were placed in a test tubes and transformed into pulp after placed in an oven at a temperature of 75°C for 24 h. Macerated fibers rinsed with distilled water, then subjected to shaking to separate the fibers and vessels for measuring. Macerated wood fragments are transported and spread over a glass slide and they were observed under microscope. A total of 200 fiber and vessel diameters were measured using microscope with DinoXcope digital camera. After evaluated the average of all parameters, the following equations were followed to calculated:

$$\textbf{Runkel ratio} = \frac{2\times\text{Fiber cell wall thickness}}{\text{Lumen width}}$$

$$\textbf{Flexibility ratio} = \frac{\text{Lumen width of fiber}}{\text{Diameter of fiber}} \times 100$$

$$\textbf{Slenderness ratio} = \frac{\text{Length of fiber}}{\text{Diameter of fiber}}$$

Statistical analysis:

Descriptive statistical analysis was conducted to determine the maximum and minimum values, means and standard deviations for all properties were calculated.

Table 1. Tree dimensions

Tree NO.	Tree Age (Years)	Tree Height (m)	Diameter of Tree at DBH (cm)	Diameter of Wood Disk at DBH without Bark (cm)
1	9	7.80	11.20	10.65
2	9	7.55	15.40	14.55
3	9	8.35	16.35	15.45
4	9	7.15	17.30	16.35
5	9	7.40	10.85	10.45
Average	9	7.65	14.22	13.49
ST.D	0.00	0.45	2.99	2.75

RESULTS AND DISCUSSION

Morphological properties

Cross-sectional area of heartwood, sapwood, bark content and annual growth ring at DBH varied among samples taken from various trees. All studied trees appear that there is indeed a difference in the proportions of heartwood and sapwood (Table 2), the mean of HWP and SWP is 69.01% and 12.93% respectively. Also experiments observed that the results of HWP were high and ranged between (83.02-90.34%) whereas, SWP was very low and ranged between (9.66-16.98%). This result was in agreement with that reported by EL-Juhany (12), as well as with others reported in different species (35, 39, and 34). Figure (1) demonstrates the coefficient of trees diameter at DBH to the proportion of heartwood and sapwood. The amount of heartwood in a tree increases rapidly with increasing the tree diameter (45). Bamber (6) proposed a physiological explanation; whoever theorizes that sapwood must be continuously laid down concurrently with the growth of the crown, its quantity can only be sustained at the optimum through the creation of heartwood, acting as a regulatory mechanism for regulating sapwood quantities. This leads to think that the above-mentioned variation in HWP and SWP may be caused by a combination of various anatomical and physiological factors (10). Bark percentage (BP) ranged amongst (7.24-10.73%) with an average 9.78 of the cross-sectional area at DBH (Table 2). It seems that the BP showed a significant variation between trees, although the age is constant for all trees (Table 2, Figure 2).

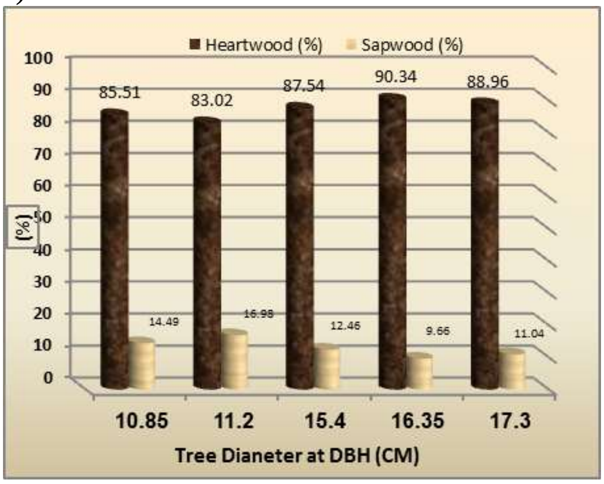

Fig. 1. Relationship between trees diameter at DBH with percentage of heartwood and sapwood

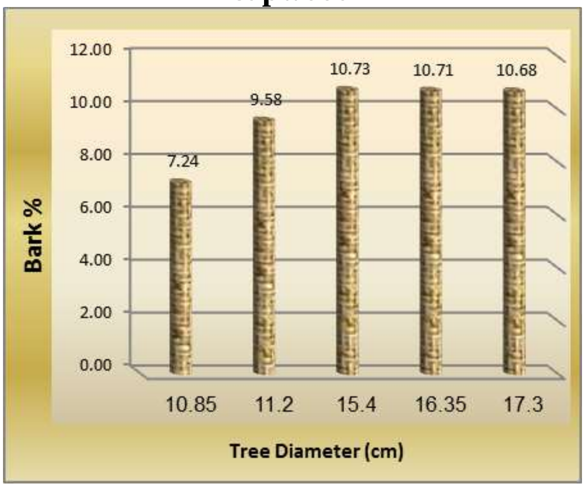

Fig. 2. Relationship between bark percentage and trees diameter at DBH

Bark thickness is associated with geographic factors, as with availability of moisture, diameter and age of the tree (53). Unlike various types of bark, they have various physiological characteristics in relation to the ecology of different species and provide variety habitats for bark living arthropods (41). The annual ring width of *M. azedarach* averaged 11.53mm, with a range between 8.43 to 16.02 mm (Table 3). It appears that there a differences in the ARW from pith to bark (Figure 3) Mean ARW close the pith was broad and rapidly decreased with age. This results are in covenant to those in literature (32, 21, and 57), reported that the wood characteristics and their difference in the stem of 17-19-year-old *M. azedarach* trees developed in northern Vietnam and Japan, respectively, and Matsumura *et al.*, (32) notice that ARW was wide near the pith up to a height of 3 m then became stable beyond the 4th ring irrespective of stem height. ARW is variable, because it is influenced by different factors, as the fluctuation in the environment (65).

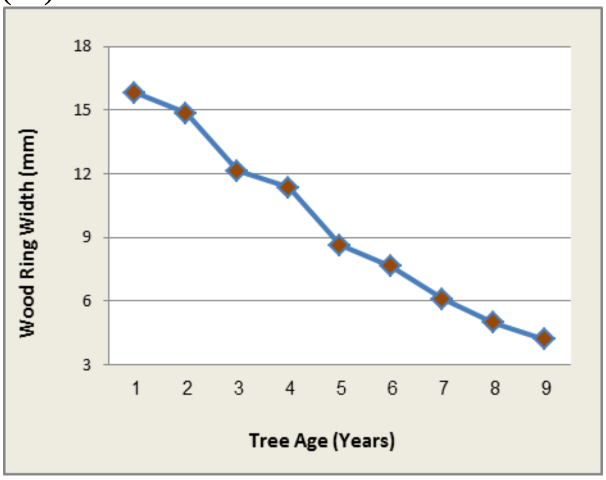

Fig. 3. Changes in annual ring width of *Melia azedarach* L. tree from pith to bark

Physical Properties

The specific gravity is regarded as a measure of wood hardness and many other properties (61). The values of wood SG and Basic WD ranged between (0.36-0.48g/cm^3) and (0.31-0.40g/cm^3) which shown in Table (2). This is in concourse to the values reported earlier in the literature (47 and 56), however El-Juhany (12), stated lower values of SG: 0.41, 0.49 and 0.40 and 0.41, respectively. Meanwhile others have noticed different values for WD of *M. azedarach*, (16, 31, and 49) respectively, described a WD of 0.46, 0.43, 0.50 and 0.65 g⁄cm^3. Dissimilarities between specific gravity and density records for the same species could be due to the age factor (9 and 22) and geographic variability effects such as temperature, precipitation and latitude (61).

Wood SG and wood WD in *M. azedarach* enlarged from pith to bark (Figures 4 and 5).

Table 2. Morphological properties of *Melia azedarach* L. trees

Tree NO.	Heartwood (cm)	Sapwood (cm)	Heartwood (%)	Sapwood (%)	Bark Thickness (mm)	Bark percentage (%)	Annual Ring Width (mm)
1	9.34	1.00	83.02	16.98	3.38	9.58	8.43
2	13.70	1.95	87.54	12.46	4.32	10.73	12.38
3	13.20	2.30	90.34	9.66	4.6	10.71	11.74
4	14.10	1.75	88.96	11.04	4.85	10.68	16.02
5	8.85	1.50	85.51	14.49	3.18	7.24	9.1
Average	11.84	1.78	69.01	12.93	4.06	9.78	11.53
ST.D	2.53	0.63	2.89	2.89	0.74	1.50	3.01

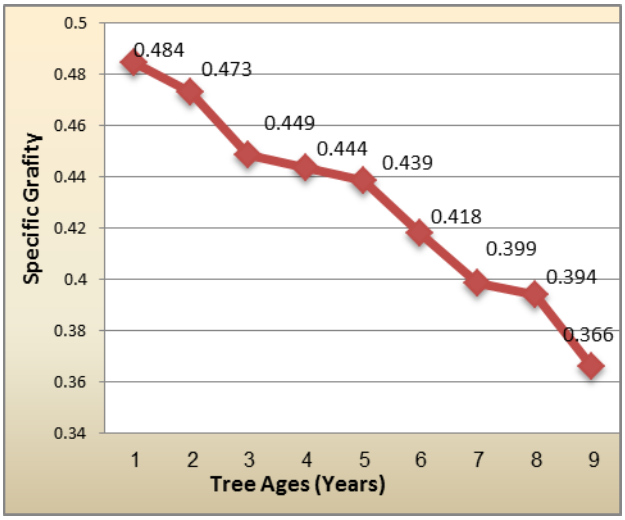

Fig. 4. Changes of wood specific gravity of *Melia azedarach* L. tree from pith to bark

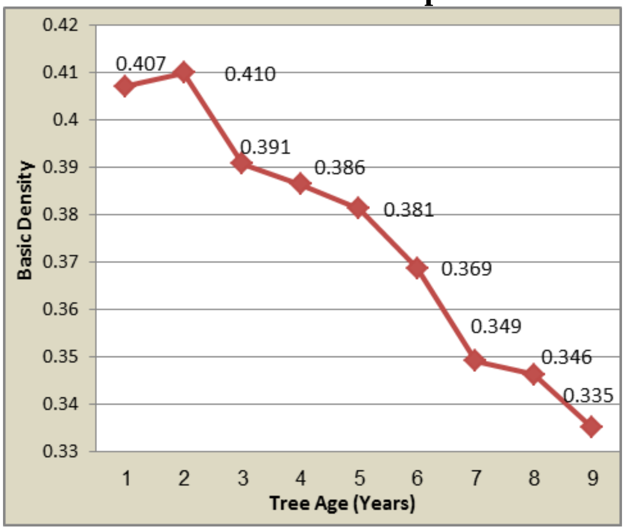

Fig. 5. Changes of wood basic density of *Melia azedarach* L. tree from pith to bark

Such results are in arrangement to those in literature (32, 12, and 58). This trend can also be seen in other species belonging to the family of Meliaceae such as *Toona ciliata* (42) and *Swietenia macrophylla* (30). Moreover, Ofori and Brentuo (43) indicated that the density of *Cedrela odorata* increased rapidly from pith to bark. It seems from Table 4, which the average volumetric shrinkage value and volumetric swelling at DBH were 13.18% and 16.25%, this result is in accordance with that reported by Praptoyo (47); Van Duong and Matsumura (57) and Almalah (3) for *M. azedarach* wood. The highest values of shrinkage can be observed, when juvenile wood is available in wood with the lowest specific gravity values and then when juvenile wood has a high shrinkage due to the cellulose molecules at a large angle away from the long and grain direction (64 and 36). The relationship between basic density and shrinkage suggests that basic density is a good predictor of dimensional stability (57). The moisture content and maximum moisture content was 44.46% and 208.36%, respectably, and Fiber Saturation Point was 36.34%. Otherwise, the *M. azedarach* has a very low proportion of the cell wall (28.05%). Therefore, it has a high ratio of porosity (71.94%), this results concurs with Nair (37); Akyildiz and Kol (2); and Kim *et al.*,(25) who reported that reducing the percentage of cell wall leads to an increase the porosity in wood and reductions the wood density. Thickness of cell wall and porosity causes the difference in the specific gravity amongst species, within a species, as well as between earlywood and latewood growth (14).

Table 3. Descriptive statistics for physical properties studied of *Melia azedarach* L. wood

Properties	Mean	Maximum	Minimum	Standard Deviation (ST.D.)
Specific gravity	0.420	0.48	0.36	0.030
Basic Density(g /cm^3)	0.36	0.41	0.32	0.026
Volumetric shrinkage (%)	13.182	17.84	6.84	2.37
Volumetric swelling (%)	16.25	21.71	7.34	3.12
Moisture content (%)	44.46	77.24	25.17	9.61
Maximum moisture content (%)	208.36	249.63	177.29	19.69
Fiber saturation point (FSP) (%)	36.34	54.41	17.45	7.75
Cell wall (%)	28.05	32.36	24.17	2.03
Porosity (%)	71.94	75.82	67.63	2.03

Anatomical properties

The dimensions of fibers and vessels are the most characteristic that are important for the variability of wood. It indicates from Table (4) that the anatomical property values were: for fiber length 0.79mm, fiber diameter 17.74µm, fiber double cell wall thickness 9.67µm, and fiber lumen diameter 8.07µm. The fiber dimension in the present research is more or less close to that found in other papers for *M. azedarach*. For example, El-Juhany (12) informed a lower mean fiber length of 0.74-0.79 mm, while Richter and Dallwitz (49), Abdul Wasim (1), and Praptoyo (47) reported that the range of fiber length was (0.80-1.65), (0.78-1.3) and (0.83) mm respectively, meanwhile Nasir (38) reported an average fiber length of 1.02mm, fiber diameter of 17.08µm, cell wall thickness 3.23µm and fiber lumen diameter 10.62µm, for *M. azedarach* grown in Pakistan which are longer than *Melia* fibers grown in Saudi Arabia (12). Talal *et al.*, (54) indicated that the range of fiber length was (0.62-1.36 mm), fiber diameter of (12.00-28.00µm) and cell wall thickness (3.00-8.00µm) and fiber lumen diameter (4.00-16.00µm) for young trees. In addition Van Duong *et al.*, (58) found an average fiber length of (0.98-1.15mm). The experimental results revealed that the fiber length of *M. azedarach* is considered medium length, which is within allowable range for hardwood fiber length that used in paper production (46). The recent result is in agreement with other previous results in different tree species (11, 50, 34, and 48). Furthermore the average value of vessel length was 241.57mm, whereas vessel diameter and vessel lumen diameter averaged (169.08µm and 158.26µm) respectively. The slenderness percentage and runkel ratio were 47.58, and 1.55, respectively. The finding results are in line with the results of LevYadun and Aloni (29) and Larson (27).

Table 4. Descriptive statistics for anatomical properties studied of *Melia azedarach* L. wood

Properties	Mean	Maximum	Minimum	Standard Deviation (ST.D.)
Fiber length (mm)	0.792	1.169	0.430	0.161
Fiber diameter (µm)	17.74	33.75	9.37	4.89
Fiber double cell wall thickness (µm)	9.67	22.50	3.75	4.30
Fiber lumen diameter(µm)	8.07	18.75	1.875	3.80
Runkel ratio (%)	1.55	4.625	0.222	1.095
Flexibility ratio (%)	47.17	81.82	11.11	16.79
Slenderness ratio (%)	47.58	101.71	19.14	15.03
Vessel length (µm)	241.57	399.88	138.42	49.13
Vessel diameter(µm)	169.08	307.60	76.90	48.14
Vessel lumen diameter(µm)	158.26	276.84	61.52	46.31

CONCLUSION

The results of the present study showed a significant variation between *Melia azedarach* trees, as well as from pith to bark, for all studied properties. It can be concluded that the morphological properties has a significant variation related to the age of trees at DBH. Since physical properties particularly, specific gravity and density showed low values, low dimensional stability and high value of volumetric shrinkage, therefore *M. azedarach* wood are not recommended for wood constriction. Otherwise may be used in production of special type of paper, due to their medium fiber length.

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