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Physical and Mechanical Characterization of Three Egyptian Woody Species

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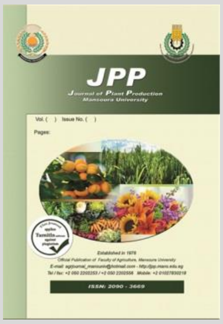

ABSTRACT

Currently, there is lack of data provided in the literature regarding the wood quality of locally grown timber trees. It is known that the wood quality varies greatly from one geographical area to another depending on the growth conditions and environmental factors. Therefore, this study aimed to characterize the wood quality of three hardwoods species; *Dalbergia sissoo* Roxb. (irrigated with treated wastewater), *Morus nigra,* and *Ficus retusa* L. grown in Egypt in order to find the possible utilization of these species. Physical and mechanical properties were compared with the internationally published data in the literature, especially those grown in their native environment of the same three genera. Density, shrinkage characteristics, modulus of rupture (MOR), maximum crushing strength (MCS) and Janka hardness in tangential and radial surfaces (H_T and H_R) were determined. Simple linear regression analyses revealed strong correlations between density and mechanical strength properties (MOR, MCS, and H_T). *M. nigra* exhibited lower mechanical performance compared with the data reported in the literature. In contrast, *D. sissoo* showed high mechanical performance, this may be a large part attributed to the irrigation with treated wastewater. However, both species fit the same uses found in the literature. In addition, this study indicates that both species also may serve as an alternative to beech and oak wood used as parquet flooring in Egypt. *F. retusa* wood can be used as a substitute for imported pine and spruce wood, which are widely used in the local market as wooden strips in the core layer of blockboards.

Keywords: *Morus nigra, Dalbergia sissoo, Ficus retusa,* physical properties, mechanical properties.

INTRODUCTION

The genus of *Ficus* belongs to the family Moraceae, this genus includes about 750 species (Semwal *et al.,* 2013). From those, *Ficus retusa* L. which is native to India (Bajpai *et al.,* 2015) and widely distributed in several parts of Egypt. This species is considered one of the most important public parks and street trees. Moreover, the crown can be formed into several shapes and its wood is generally used as firewood.

Black mulberry (*Morus nigra*) is an evergreen tree belongs to the family Moraceae, this genus contains 68 species and broadly distributed in several parts of the world. Moreover, the fruits of these species are edible and the trees are planted for silk production. The origin of its varieties are in the regions of China, Japan and the Himalayan foothills (Awasthi *et al.,* 2004; Mabberley, 2008; Sánchez, 2002).

Dalbergia sissoo Roxb. trees belong to the family Fabaceae, the trees have been used for a long time in traditional medicine. This species is native to India, Nepal, and Pakistan and the wood of this species is commonly called North Indian rosewood (Husen, 2009).

The demand for wood and wood products has been increasing from year to year due to the significant population increase in Egypt. This certainly requires the import of adequate quantities of wood to meet the needs of the population or planting trees that produce high-quality wood which can compete with those imported woods.

There are many attempts at the global level to assess the quality of locally grown timber in each country to find the optimal use of each wood species as well as the evaluation of lesser-known species. These attempts may lead to finding alternatives to the imported woods that will positively affect the provision of the foreign currency and local product support.

Wood has been used throughout history in many applications such as furniture manufacturing, construction, boatbuilding, woodworking, and other important uses. The physical, mechanical and chemical properties of wood, in addition to various aesthetic properties gave it the versatility in use (Asdrubali *et al.,* 2017; Shmulsky and Jones, 2011).

It is noteworthy to mention that not all woods have the same properties this mainly due to that it is made up of cells of different shapes and sizes (Shmulsky and Jones, 2011). It is also known that wood is a biological material which properties vary according to the environmental conditions and genetic factors (Zobel and Van Buijtenen, 2012). It is therefore necessary to evaluate the quality of the wood in each geographical area to determine the suitability of the timber of these species for commercial use. Generally, the quality of timber and its end-use can be assessed through the mechanical and physical properties.

Lack of full knowledge on the properties of locally grown timber trees may lead to inappropriate use and wasting of these renewable resources. For example, in Egypt, *Morus* spp wood is being used for a long time in boats manufacturing and in the recent years, the use of this wood has been observed for coal production in large quantities. In addition, there is no data found in literature

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about the wood quality of *Dalbergia sissoo* Roxb. grown under treated wastewater irrigation system. *Ficus retusa* wood is extensively planted in Egypt but the tree is only used for its environmental importance, but there is insufficient information about the wood quality of this species globally or in Egypt. Therefore, this study focused on these three genera. This research addresses the question of whether the wood quality of three hardwood tree species; *Dalbergia sissoo* Roxb. (grown under treated wastewater irrigation system), *Morus nigra*, and *Ficus retusa* L. grown in the Egyptian environment is comparable or not with the international data recorded for the same tree species especially those grown in their native environment.

MATERIALS AND METHODS

Three available tree species were used in this study; *Dalbergia sissoo* Roxb., *Morus nigra*, and *Ficus retusa* L. Table (1) shows the logs diameter and the site of growth in Egypt for each tree species. Both *M. nigra* and *F. retusa* stemwood logs were collected from a stock prepared for charcoal production. *D. sissoo* logs were collected from the Egyptian-Chinese friendship forest plantation located in Sadat city, Monoufia governorate grown under treated wastewater irrigation system.

The logs were converted into boards, and then were stacked for air-drying under laboratory environmental conditions. The physical and mechanical destructive tests were conducted using small clear specimens according to the British standard (BSI 373, 1957). All samples were free from any natural defects such as knots and drying checks. The mechanical tests include modulus of rupture (MOR), maximum crushing strength (MCS), and Janka hardness on tangential (HT) and radial (HR) surfaces. A universal testing machine (Amsler type with 4000 kg loading capacity) was used to perform the tests. All samples for density and mechanical properties were kept under fixed environmental conditions to reach a moisture content of 12%. The wood density and mechanical properties were calculated using the following equations.

Table 1. The diameter, tree age and location of the collected logs for this study.

Items	Number of collected logs	Diameter outside bark (cm)	Site of growth	Age (year)
Dalbergia sissoo Roxb.	5	18.5-20	The Egyptian-Chinese forest, Saddat city, Monoufia, Egypt (grown under treated wastewater irrigation system).	18
Morus nigra	6	30-35	Kafr El-Sheikh, Egypt.	25- 27
Ficus retusa L.	6	33-37	Alexandria, Egypt.	30-34

$$\rho = \frac{M_{12}}{V_{12}} \quad (1)$$

Where ρ, is wood density, M_{12} and V_{12} are mass and volume at 12% moisture content.

For shrinkage experiment, wood blocks with dimensions of 20 (T) x 20 (R) x 60 (L) mm were prepared. The shrinkage was measured in three directions, tangential, radial, and longitudinal from green to oven-dried state according to equation (2).

$$\beta_{T,R,or\ L}(\%) = \frac{(\beta_S - \beta_\circ)}{\beta_\circ} x100 \quad (2)$$

Where, β (%) is the shrinkage measured in tangential (T), radial (R), or longitudinal (L) directions; β_S is the green swollen length, $\beta_\circ$ is the oven-dry length. For volumetric shrinkage, the volume was used instead of length using the same equations.

The maximum load and the cross-sectional area were measured to calculate the modulus of rupture (MOR) following equation 3,

$$MOR = \frac{1.5 P_{max} L}{bh^2} \quad (3)$$

Where: MOR= modulus of rupture, P_{max}= maximum load, L= test span, b= specimen width, and h= specimen height.

The maximum crushing strength (MCS) was calculated using the following formula:

$$MCS = \frac{P_{max}}{A} \quad (4)$$

Where: P_{max}= maximum load, and A= cross sectional area

The hardness test (Janka test) was performed through inserting a ball with a diameter of 11.28 mm to a depth of half of the ball's diameter. The maximum load required to insert the ball into the wood was recorded. The force was loaded on tangential and radial surfaces.

RESULTS AND DISCUSSION

The results of the physical properties values are listed in (Table 2). Shrinkage and swelling affect significantly the end-use of wood. Therefore, the dimensional instability of wood is an important property to be determined (Eckelman, 1998). Wood is an anisotropic material and hence the shrinkage and swelling are often measured on the three principles axes (tangential, radial, and longitudinal) (Walker, 2006).

It is clear that the shrinkage values in the three principal directions (tangential, radial, and longitudinal) are higher in *M. nigra* than the other two species; they are in the following order, *M. nigra* > *D. sissoo* > *F. retusa.* As seen in (Table 2), the lowest values were observed for *F. retusa*, this would allow it to be dimensionally stabilized. In some applications, it is desirable to use lower shrinkage wood species; this will cause a minimum change in dimensions for wood in service or during the drying process. The coefficient of anisotropy (T/R ratio) and the overall volumetric shrinkage clearly confirmed this trend. From a technological point of view, lumber is classified according to the T/R swelling ratio as follows, favorable (< 1.6), normal (1.6-2), and unfavorable (> 2)(Noack *et al.*, 1973) . In general, the normal range of longitudinal shrinkage from green to oven dry condition is 0.1-0.3% for most of wood species (Skaar, 2012). Moreover, the value of shrinkage also varies among species as well as between trees of the same species.

It is important to indicate that the longitudinal shrinkage values are much higher in reaction wood (in this case tension wood) and this must be taken into account when such cases exist in the wooden members used for construction purposes (Skaar, 2012). In general, the tangential and radial shrinkage values for medium density woods are 2-6 and 5-10%, respectively. (Walker, 2006). The variability in shrinkage can be attributed in large part by the variation of density and microstructure (Rowell, 2012).

Table 2. Physical properties values of *Dalbergia sissoo* Roxb., *Morus nigra*, and *Ficus retusa* wood.

Items	N	Density (kg.m^{-3})	β_T(%)	β_R (%)	β_L (%)	T/R	β_V (%)
Dalbergia sissoo Roxb.	25	728.40 (38.65)	6.63 (0.79)	3.88 (0.52)	0.15 (0.079)	1.72 (0.1)	10.66 (1.24)
Morus nigra	25	640.4 (33.8)	8.31 (0.76)	4.32 (0.38)	0.26 (.064)	1.92 (0.088)	12.89 (1.1)
Ficus retusa L.	17	461.67 (26.42)	5.21 (0.47)	3.55 (0.91)	0.11 (0.469)	1.47 (0.45)	8.87 (1.00)

*** Values in parenthesis are standard deviation; β_T,β_R,β_L,β_V are the shrinkage from green to oven-dried condition in the tangential, radial, longitudinal, and volumetric directions, respectively.**

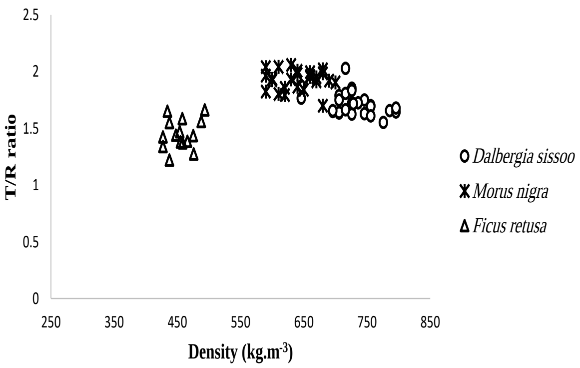

Figure 1. Relationship between density and T/R ratio.

Several studies have indicated that there is significant linear relationship between density and volumetric shrinkage of wood (Bossu *et al.*, 2016; Kiaei, 2012; Skaar, 2012). This indicates that, the density affects significantly the shrinkage characteristics. It is noteworthy to mention that the type of measured density such as dry or basic can affect the strength of the relationship between density and shrinkage (Kärkkäinen and Marcus, 1985). There is little information in the literature about the prediction of T/R ratio using wood density. Therefore, this study investigated this relationship for the three species. The relationship between T/R ratio and density for the three tested genera is illustrated in (Figure 1). It is obvious from the graph that there is no meaningful relationship between the two parameters for the three tested genera. Therefore, the density cannot be used as a predictor of the T / R ratio for the three tested genera. The results were in agreement with (Tuisima-Coral *et al.*, 2017) who found insignificant correlation between T/R ratio and basic density and specific gravity of *Guazuma crinite* wood. In contrast, (Van Duong and Matsumura, 2018) found linear positive correlation between T/R ratio and basic density of *Melia azedarach* wood. In contrast, (Yamashita *et al.*, 2009) found weak negative correlation (r=-0.342) between basic density and T/R ratio of sugi (*Cryptomeria japonica*) wood. Actually, the density is not the only factor that affect the shrinkage properties but also the percentage of sapwood to heartwood and the microfibril angle in the S2 layer of the secondary cell wall (Sadegh *et al.*, 2012)

The other physical property tested in this study is wood density; it is an important parameter to be used for wood quality characterization. Largely, wood density determines the suitability of a species for a specific end use. High-density wood commonly used for structural applications because the mechanical properties are associated with the density. Another importance for knowing the density value for each wood species for determination of shipping weights for the exported woods (Simpson, 1993). In general, the density of wood cell wall is approximately 1.5 g.cm^{-3} however; the variability in density among wood species is associated with the amount of intra- and extracellular spaces.

The highest values for density were recorded for *D. sissoo* and the lowest values were recorded for *F. retusa*. The mean density values were found to be 728.4, 640.4, and 461.67 kg.m^{-3} for *D. sissoo*, *M. nigra*, and *F. retusa*, respectively. According to the classification of woods by density (Lincoln, 1986), *M. nigra* and *F. retusa* were belongs to the light medium group and *D. sissoo* belongs to heavy woods. The average density of *M. nigra* wood grown in Slovakia was 623 kg.m^{-3} (Čulík *et al.*, 2015) which is lower than the value reported in the current study. The density values reported in (Table 4) for the three species grown in their native environment were 801, 690, and 350-640 kg.m^{-3} for *D. sissoo*, *M. nigra*, and *F. retusa*, respectively.

The mean mechanical strength properties and their standard deviation for the three species are presented in (Table 3). The average values of modulus of rupture (MOR) were 115.93, 70.27, and 38.64 N.mm^{-2} for *D. sissoo*, *M. nigra*, and *F. retusa*, respectively. The MOR values reported in (Table 4) for *D. sissoo*, *M. nigra*, and *F. retusa* grown in their native environment are 97.5-109, 80.6, and 42 N.mm^{-2}, respectively. The same trend was observed in the other strength properties, as seen from (Table 3). The other strength properties (MCS, H_T, and H_R) are in the following order, *D. sissoo*> *M. nigra* >*F. retusa*.

Table 3. Mechanical properties average values of *D. sissoo*, *M. nigra*, and *F. retusa* wood.

Item	N	MOR (N.mm^{-2})	MCS (N.mm^{-2})	Janka hardness (N)		Hardness ratio	Hardness difference
				H_T	H_R	T/R	H_T-H_R
Dalbergia sissoo Roxb.	25	115.93 (3.85)	58.32 (3.35)	6481.72 (300.6)	6359.56 (298.3)	1.019 (0.0062)	122.16 (38.96)
Morus nigra	25	70.27 (2.34)	45.14 (4.00)	5950.12 (246.7)	5797.72 (231.9)	1.025 (0.0068)	152.40 (43.38)
Ficus retusa	17	38.64 (3.52)	29.94 (3.67)	1350.71 (98.8)	1295.68 (69.7)	1.041 (0.044)	55.04 (56.15)

MOR, MCS, H_T, and H_R are modulus of rupture, maximum crushing strength, tangential hardness, and radial hardness, respectively.

To determine the quality of wood produced from the locally grown trees, it should be compared to the quality of those grown in their native environment or at least grown close to it.

For example, the MOR, MCS, and Janka hardness values of *D. sissoo* wood grown in Bangladesh were found to be 109.83 $N.mm^{-2}$, 54.92 $N.mm^{-2}$, 6374.3 N, respectively (Rauf and Raza, 2012), those values are lower than the measured values in the current study. Moreover, the values of MOR and MCS in this study are higher than those reported in (Table 4) by (Meier, 2019).

Although the *D. sissoo* grown in Monoufia and irrigated with treated wastewater aged 18 years old, however, it has higher strength values except for hardness than the same species grown in El-Saff region, Giza, Egypt in a study performed by (Awaad, 1973). Of course the geographic region affects wood quality mainly, the physical and mechanical properties (Barnett and Jeronimidis, 2009; Shmulsky and Jones, 2011). Likewise, the irrigation with treated wastewater may have a significant effect on increasing the strength properties. For instance, in a study performed by (Singh and Bhati, 2005) to examine the effect of the application of municipal effluent on the growth of *D. sissoo* seedlings, they found it had a positive increase in growth and biomass.

The average values of MOR, MCS, H_T, and T_R for *M. nigra* were found 70.27 $N.mm^{-2}$, 45.14 $N.mm^{-2}$, 5950.12 N, and 5797.72 N, respectively. The values reported by (Meier, 2019) for unspecified species of *Morus* (Table 4) were higher than the value obtained from the locally grown *M. nigra*.

In general, there is little data recorded for the properties of *F. retusa* wood in literature. Therefore, this study introduces a comprehensive information about this species to suggesting its possible uses. In general, *F. retusa* exhibited low mechanical performance compared with the other two species in this study.

As previously mentioned, wood is an anisotropic material and hence Janka hardness test was performed on both tangential and radial surfaces to give more comprehensive information about this test on these materials. Both of *D. sissoo* and *M. nigra* have close hardness values on both tangential and radial sides. The average values of hardness test for the three genera were higher in tangential surface than the radial surface. The ratio of H_T/H_R were 1.019, 1.025, and 1.041 for *D. sissoo*, *M. nigra*, and *F. retusa*, respectively.

The obtained values are close to some wood materials used for parquet flooring in Egypt. For instance, the hardness values listed in (Table 4) for European beech (*Fagus sylvatica*), American beech (*Fagus grandifolia*), and red oak (*Quercus rubra*) are 6410 N, 5800 N, and 5730 N, respectively. Therefore, both of *D. sissoo* and *M. nigra* may be suitable as an alternative to those imported woods for parquet flooring. Therefore, the extensive in the planting of these two species may play an important role in the Egyptian parquet flooring market. In addition, *D. sissoo* wood is reported to be durable to very durable (Meier, 2019) as well as due to the high MCS it could be used as piles.

This study has shown that wood of *D. sissoo* from trees irrigated with treated wastewater and *M. nigra* have physical and mechanical properties values comparable with those of grown in native environment. Generally, the selected mechanical properties values of *F. retusa* wood appeared to be very low. On the other hand, the results obtained for *D. sissoo* and *M. nigra* had higher mechanical performance.

Table 4. Mechanical and physical properties for the same genera tested in this study and another selected species grown in their native environment.

Items	**Density**	**MOR ($N.mm^{-2}$)**	**MCS ($N.mm^{-2}$)**	**Hardness (N)**	β_T **(%)**	β_R **(%)**	β_V **(%)**
Fagus sylvatica	689(1)	118(1)	56.3(1)	6410(1)	7.6(2)	2.8(2)	-
Fagus grandifolia	640(3)	103(3)	50.3 (3)	5800(3)	11.9(3)	5.5(3)	17.2(3)
Quercus rubra	705(4)	99 (4)	46.6(4)	5738(4)	8.6 (4)	4.00(4)	13.7(4)
Ficus spp	350-640(5)	42(5)	24.9(5)	-	2.2(5)	1.00(5)	-
Morus spp	690(6)	80.6(6)	48.2(6)	7470(6)	6.6(6)	3.3(6)	10.3(6)
Dalbergia sissoo Roxb.	770(6)	97.5(6)	55.5(6)	7380(6)	5.3(6)	3.1(6)	8.4(6)
Dalbergia sissoo Roxb. *(*grown in Bangladish)	801(7)	109.83(7)	54.92(7)	6 374.3(7)	4.9-5.6(8)	2.7-3.4(8)	-
Dalbergia sissoo (grown in EL-Saff, Giza, Egypt).	770(9)	101.87(9)	45(9)*	6 791.1(9)	-	-	-

(Lavers, 1983) (1) ; (Entrican *et al.*, 1951) (2) ; (Kretschmann, 2010) (3) (Alden, 1995) (4); (MTIB, 1986) (5);(Meier, 2019) (6);(Rauf and Raza, 2012) (7) ; (Louppe *et al.*, 2008) (8); (Awaad, 1973) (9);* calculated value from the original source.

It is clear from (Table 3), that the mechanical properties for the three species ranked in the following order *D. sissoo* > *M. nigra* > *F. retusa*. It is noticeable that *F. retusa* has very low mechanical performance. Therefore, the wood cannot be used in any structural applications. However, this wood has good appearance and easy working properties with machine tools without any problems. Thus, this wood may be joined side to side for nonstructural applications such as drawers and small wooden tables. It is worth mentioning that the manufacture of blockboards in Egypt depends on the use of wooden strips, mostly imported pine or spruce wood. Some factories face a problem during the manufacture of this product when applying heat to this wood during drying or hot pressing, the natural resins exist in the internal structure of wood migrate to the surface and hinder the process of adhesion with the synthetic resins. Thus, this will affect the final product quality. There are of course many techniques to overcome this problem but they are expensive. Currently, there are challenges globally facing some factories in providing raw materials that have long been used in the production of wood products, for example, one of the famous factories in Germany was producing LVL from softwood species for a long time and recently began to produce it from beech (one of hardwoods group) (Hughes, 2015). It is already known that the core layer of blockboard is usually made from softwood strips; however, recently it is noticeable in the global wood products market there are products based on core hardwood species. Therefore, based on the results of physical (density and shrinkage characteristics) and mechanical properties of *F. retusa* wood it may be a suitable alternative to these imported woods and does not exhibit these problems during exposure to heat because it does not contain natural resin canals in its structure. A correlation analysis was used to evaluate the correlation between density and the selected mechanical properties (MOE, MOR, MCS, and H_T).

Table 5. Linear regression equations for the effect of wood density on the mechanical properties.

Items	Regression equation	r^2	r
Density-MOR	y = 0.0634x + 9.665 (*D. sissoo*)	0.84	0.92
	y = 0.0681x + 35.322 (*M. nigra*)	0.49	0.70
	y = 0.1256x - 19.327 (*F. retusa*)	0.8	0.89
Density-MCS	y = 0.1057x - 5.5566 (*D. sissoo*)	0.8	0.89
	y = 0.0751x + 12.649 (*M. nigra*)	0.75	0.85
	y = 0.131x - 30.512 (*F. retusa*)	0.89	0.94
Density-H_T	y = 6.7759x + 1196.2 (*D. sissoo*)	0.76	0.87
	y = 5.8535x + 2201.5 (*M. nigra*)	0.65	0.81
	y = 3.1266x - 92.749 (*F. retusa*)	0.70	0.84

r^2, is coefficient of determination and r, is correlation coefficient.

The regression models were (y= a+bx). Significant positive correlations were found between the density and the selected mechanical properties (MOE, MOR, MCS, and H_T). All correlation coefficients were above 0.70, indicates high correlation. Thus, the models reported herein can be used for reliable prediction. In addition, the coefficient of determination was included in (Table 5) to show how the percentage of variation in each mechanical strength property could be explained by density.

CONCLUSION

This study aimed to provide information about the quality of three tree species; grown under the Egyptian environment to optimize the utilization of these species. The mechanical and physical properties for the three species were evaluated. The results showed that the mechanical properties of *Dalbergia sissoo* grown under treated wastewater irrigation system exceeded the same species grown in their native environment. In contrast, the mechanical performance for *Morus nigra* were lower than the internationally reported data for the same genus. Due to the high hardness values of both *D. Sissoo* and *M. nigra* it can be good alternatives for beech and oak woods as flooring parquets in Egypt. Based on the obtained results of the physical and mechanical properties of *Ficus retusa* wood, the study introduced this wood to be used in the blockboard industry as an alternative to the imported pine or spruce wooden strips. Moreover, strong relationships were found between density and the selected mechanical properties tested in this study. The results of linear regression analysis revealed that the density cannot be used to predict the value of the coefficient of anisotropy (T/R ratio) for the three tested genera.

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التوصيف الفيزيائي والميكانيكي لثلاثة أنواع خشبية مصرية

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في الوقت الحالي، هناك نقص في البيانات المقدمة في المراجع العلمية والمتعلقة بجودة الاخشاب للأشجار المزروعة محليًا. ومن المعروف ان جودة الاخشاب تختلف بدرجة كبيرة من منطقة جغرافية لأخرى تبعا لظروف النمو والعوامل البيئية. لذلك تهدف هذه الدراسة إلى تقييم صفات الخشب لثلاث انواع من الاشجار الصلدة النامية محليا وهي اشجار السرسوع (المروية بمياه الصرف الصحي المعالجة)، التوت الاسود والفيكس العادي من أجل التعرف على الاستخدام المحتمل لها. تم مقارنة الخواص الفيزيائية والميكانيكية مع البيانات المنشورة دوليًا في المراجع العلمية، وخاصة تلك النامية في بيئتها الأصلية من نفس الأجناس الثلاثة. تم تقدير الكثافة، الانكماش في المحاور الرئيسية الثلاثة (الطولى والقطرى والمماسى) ، معامل الكسر، المقاومة القصوى للتهشم والصلادة في الاتجاه المماسي والقطري. أشارت النتائج الى ان خشب السرسوع والتوت الاسود لهم خصائص مقاومة ميكانيكية عالية بالمقارنة بخشب الفيكس. أوضحت تحليلات الارتداد الخطي البسيط وجود ارتباط قوي بين الكثافة وخصائص المقاومة الميكانيكية. أظهر خشب التوت الاسود اداء فى السلوك الميكانيكى أقل مقارنة مع البيانات المسجلة لنفس النوع فى المراجع العلمية الدولية، فى المقابل اظهر خشب السرسوع أداءً ميكانيكياً عاليًا، وقد يعزى السبب فى ذلك بدرجة كبيرة الى ان تلك الاشجار مروية بمياه الصرف الصحي المعالجة. ومع ذلك، فإن كلا النوعين يناسب نفس الاستخدامات الموجودة في المراجع العلمية الدولية بالإضافة إلى ذلك، تشير هذه الدراسة إلى انه يمكن استخدام كلا النوعين كبديل لخشب الزان والارو المستخدم كأرضيات خشبية في مصر .يمكن استخدام خشب الفيكس العادى كبديل لأخشاب السويد والبياض المستورد والمستخدم بكثرة فى السوق المحلية كسدائب خشبية فى طبقة القلب من الواح خشب البانوه (Blockboard).