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Ailanthus excelsa: An alternate tree species for plywood production

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Abstract
The data on physical and mechanical properties of *Ailanthus excelsa* (10 yr old) have shown that the mean value for green wood density and drywood density ranged from 839.48 Kg m^{-3} to 846.97 Kg m^{-3} and from 390.19 Kg m^{-3} to 429.07 Kg m^{-3} respectively. The static bending strength ranged from 319.39 Kg cm^{-2} to 347.86 Kg cm^{-2}, tension parallel to grain ranged from 376.86 Kg cm^{-2} to 396.04 Kg cm^{-2} and tension perpendicular to grain ranged from 109.24 to 124.87 Kg cm^{-2} for different girth classes of wood. The compression strength parallel and perpendicular to grain ranged from 298.70 to 325.36Kg cm^{-2} and 102.47 to 114.69 Kg cm^{-2} respectively. The maximum veneer recovery of 60.95% in higher girth class (90-120 cm and minimum veneer recovery of 45.72% was in lower girth class (30-45 cm) and the veneer shrinkage ranged from 4.57% to5.82% for different girth class. Regarding physical properties of plywood, the plywood density ranged from 613 to 711 Kg m^{-3}; water absorption from 16.37 to 18.58% and thickness swelling from 3.80 to 4.54% in which the plywood density is directly proportional to girth class whereas thickness swelling and water absorption are inversely proportional to girth class. The mechanical properties of plywood are the paramount parameters for the use of plywood as a structural material. The modulus of elasticity varied from 42277 to 5024 N mm^{-2}, modulus of rupture ranged from 29.71 to 34.68 N mm^{-2} and glue shear strength was from 119 to 1318 N mm^{-2} for different girth classes. The conclusion which could be drawn from this study is that *Ailanthus excelsa* wood has shown nearer physical and mechanical properties to the IS 1708 standard. Hence, *Ailanthus excelsa* wood could be used as core veneer for manufacturing plywood.

Keywords: *Ailanthus excelsa*, physical and mechanical properties, plywood properties

Introduction
The wood is an important material that can be used in different forms and situations. Its characteristics are comparable to those of other structural materials, but increased demand for wood has caused a decrease in forest resources. One way to increase forest resources, thereby protecting the natural forest wherein composite products especially plywood has been developed as an alternative to solid products. The plywood has increased dimensional stability, uniformity and higher mechanical strength, improved stress distributing properties, reduced processing cost and better appearance.

Although timber is the principle raw material for manufacturing of plywood, all timber species are not suitable for large scale manufacture of any type of plywood. In addition, there is a huge demand for plywood due to ever increasing real estate sector. In this juncture, it is highlighted that Ailanthus wood is well suited for cabinet making. The wood of mature ailanthus trees is of proven quality for cabinet work and other types of interior work in house construction (Kumar *et al.*, 2010) [7]. This besides, this species wood is easily workable with tools and glue and takes a finish well. It has been proven that the strength of this species wood offers the ability to be used in the construction of a wide variety of wooden structures (Barboutis and Vasileiou, 2009) [4]. Although the live tree tends to have quite flexible wood, this wood gets quite hard being properly dried and it has been proven that the strength of this species wood offers the ability to be used in the construction of a wide variety of wooden structures. Considering the properties of Ailanthus wood and specifically the properties of plywood in various literature, this study was conducted with the objective of assessing the plywood properties of *Ailanthus excelsa* of different girth classes.

Materials and Methods
Ailanthus excelsa of 10 year old trees were selected and the logs were categorized into three different girth classes viz., 30-45 cm, 45-90 cm and 90-120 cm with four replications.

The physical properties viz., volume, green wood density, dry wood density and moisture content and the mechanical properties viz., static bending strength, tensile parallel to grain, tensile perpendicular to grain, compression parallel to grain and compression perpendicular to grain were determined. The wood mechanical properties determines the quality of veneer and plywood. Hence, the mechanical properties of Ailanthus wood were assessed on Universal Timber Testing Machine in accordance with IS 1708.

The maximum static bending strength was calculated by dividing the load to failure by the cross sectional area of the specimen. The specimen size for measuring the tension parallel to grain was 32.5 x 5 x 1.5 cm. The specimen size for measuring tension perpendicular to grain was 32.5 x 5 x 2 cm. The compression strength parallel to grain was carried out using the specimen size of 2 x 2 x 30 cm. The following plywood properties viz., veneer recovery, veneer shrinkage, thickness swelling, water absorption, density, modulus of elasticity across the grain, modulus of rupture across the grain, modulus of elasticity along the grain, modulus of rupture along the grain and glue shear strength were assessed as per the standard procedure.

Results and Discussion

The data on physical and mechanical properties of *Ailanthus excelsa* (10 yr old) have shown that the mean value for green wood density ranged from 839.48 Kg m^{-3} to 846.97 Kg $m^{-3.}$ Among the three girth classes, T_3 (90-120 cm) showed significantly higher green wood density when compared to other girth classes (30- 45cm cm and 45-90 cm).The same trend was noticed for dry wood density. The highest dry wood density of 429.07 Kg m^{-3} was noticed in T_3 whereas the lowest dry wood density (390. 19 Kg m^{-3}) in $T_{1.}$

The reverse trend was observed in moisture content of wood wherein it was lower (49.50%) in T_3 and higher (53.51 %) in T_1 (Table 1). The wood density values increased gradually with increase in girth size. The findings are in accordance with other species *viz*., *Melia dubia* (Saravanan *et al*., 2014) [8], Teak (Izekor *et al*., 2010) [6], *Acacia auriculiformis* (Shukla *et al*., 2007), *Nauclea diderichii* (Fuwape and Fabiyi, 2003) [5] and in *Gmelina arborea* Akachuku (1980) [2].

Table 1: Physical properties of *Ailanthus excelsa wood*

Treatments (Girth classes)	Green wood density (Kg m^{-3})	Dry wood density (Kg m^{-3})	Moisture Content (%)
T_1 (30-45cm)	839.48	390.19	53.51
T_2 (45cm-90 cm)	842.49	413.09	50.75
T_3 (90 cm- 120 cm)	846.97	429.07	49.50
SEd	0.372	0.355	0.258
CD (0.05)	0.784	0.747	0.541

The mean values for static bending strength was 319.39 Kg cm^{-2}, 326.76 Kg cm^{-2} and 347.86 Kg cm^{-2} for different girth classes viz., 30-45cm, 45-90 cm and 90-120 cm respectively. It was observed that the static bending strength improves with increase in girth size. The results revealed that the tension parallel to grain increased with increase in girth of wood. Among the three girth classes, significantly higher static bending strength was recorded in T_3 compared to T_1 and T_2. The maximum tension parallel to grain was recorded in T_3 (396.04 Kg cm^{-2}) and the minimum (376.86 Kg cm^{-2}) in $T_{1.}$

The increase in MOE with girth size may be attributed to increments of growth rings, addition of more mature wood and the increasing age of cambium as the tree grows in girth. Wood that has a high modulus of elasticity indicates that it is difficult to bend. Similar trend of increase in MOE has been reported in *Melia dubia* (Saravanan *et al*., 2014) [8], Teak (Izekor *et al*., 2010) [6], *Acacia auriculiformis* (Shukla *et al.*, 2007), *Nauclea diderichii* (Fuwape and Fabiyi, 2003) [5] and Slash pine (Macpeak *et al.,* 1990). The mean values of compression strength parallel to grain in Ailanthus wood were 298.70 Kg cm^{-2}, 314.91 Kg cm^{-2} and 325.36 Kg cm^{-2}) for different girth classes. This study showed that significantly higher value was recorded in T_3 and lower value in T_1.The similar trend was noticed in compression perpendicular to grain with the mean values ranged from 102.47 to 114.69 Kg cm^{-2} (Table 2).The current study shows that compressive strength increases with increase in girth size which is in accordance with the findings of Saravanan *et al*., (2014) [8] in *Melia dubia*, Izekor *et al*., (2010) [6] in Teak and Shukla *et al.* (2007) in *Acacia auriculiformis*.The result of the present investigation is in consonance with the results of Saravanan *et al*., (2014) [8] in *Melia dubia*, Izekor *et al*., (2010) [6] in *Tectona grandis*, Fuwape and Fabiyi (2003) [5] in *Nauclea diderichii.* MOR values increased with girth size which may be due to annual rings, addition of more mature wood and the increasing age of cambium as the tree grow in girth (Izekor *et al.*, 2010) [6].

Table 2: Mechanical properties of *Ailanthus excelsa* wood

Treatments (Girth classes)	Static Bending strength (Kg cm^{-2})	Tension parallel to grain (Kg cm^{-2})	Tension perpendicular to grain (Kg cm^{-2})	Compression parallel to grain (Kg cm^{-2})	Compression perpendicular to grain (Kg cm^{-2})
T_1 (30-45cm)	319.39	376.86	109.24	298.70	102.47
T_2 (45cm-90 cm)	326.76	384.75	112.39	314.91	108.66
T_3 (90 cm- 120 cm)	347.86	396.04	124.87	325.36	114.69
SEd	0.544	0.177	0.239	0.192	0.235
CD (0.05)	1.144	0.373	0.503	0.403	0.449

The veneer properties play a vital role with regard to plywood production. In this study, the veneer recovery in different girth classes of Ailanthus was assessed and it showed that there was a significant difference in veneer recovery among the girth classes. The maximum veneer recovery (60.95%) was obtained in higher girth class (90- 120 cm) and minimum (45.72 %) in lower girth class (30- 45 cm). Regarding veneer shrinkage, T_3 recorded minimum shrinkage with a value of

4.57% as against 5.82 % in T_1 (Table 3). In the present investigation, plywood manufactured from wood of all girth class showed nearer to prescribed standards, which endorse the suitability of *Ailanthus excelsa* wood for plywood production. For all the parameters, there was an increase in values with increase in girth size. It may be due to the reason that as tree grows continuously and wood changes from juvenile to mature, the strength properties also gets improved (Tenorio *et al*., 2011) [13].

Table 3: Veneer recovery and veneer shrinkage in *Ailanthus excelsa*

Treatments (Girth classes)	Veneer recovery (%)	Veneer shrinkage (%)
T_1 (30-45cm)	45.72	5.82
T_2 (45cm-90 cm)	52.90	5.08
T_3 (90 cm- 120 cm)	60.95	4.57
SEd	0.256	0.072
CD (0.05)	0.538	0.151

The dimensional stability of plywood closely related to thickness swelling, water absorption and density. In this study, the thickness swelling was minimum in T_3 (3.80%) and maximum in T_1 (4.54%). It was observed that the mean value of water absorption for T_1, T_2 and T_3 was 18.58%, 17.77% and 16.37% respectively.The water absorption of Ailanthus plywood was significantly lower in T_3 when compared to other two girth classes. The variation in water absorption is mainly attributed to the difference in cellulose and hemicellulose content in Ailanthus wood (Table 4).

The density of plywood was directly proportional to girth classes where significantly highest density was noticed in T_3 (711 Kg m^{-3}) and the lowest was observed in T_1 (613 Kg m^{-3}) (Table 4). The results obtained in the current study are within the standard range. Similar density is reported in plywood of other fast growing species *viz*., *Bombax Ceiba* (0.50 g cm^{-3} and 0.54 g cm^{-3}) (Rahman *et al*. 2014 a, Alam *et al*., 2012) [10], in *Melia azedarach* (0.54 g cm^{-3}) (Rahman *et al*., 2014 b) [10] and *Gmelina arborea* (0.516 g cm^{-3}) (Tenorio *et al*., 2011) [1] which endorse the findings of current study.

Table 4: Physical properties of *Ailanthus excelsa plywood*

Treatments (Girth classes)	Thickness swelling (%)	Water absorption (%)	Density (Kg m^{-3})
T_1 (30-45cm)	4.54	18.58	613
T_2 (45cm-90 cm)	4.18	17.77	671
T_3 (90 cm- 120 cm)	3.80	16.37	711
SEd	0.050	0.88	1.348
CD (0.05)	0.105	0.185	2.833

The mechanical properties of Ailanthus plywood were assessed and the results were presented in table 5. The modulus of rupture and the modulus of elasticity are the paramount parameters for the use of plywood as a structural material. The modulus of rupture is an indication of bending strength of plywood and whereas the modulus of elasticity is an indication of stiffness. The modulus of elasticity across the grain was significantly maximum in T_3 (5024 N mm^{-2}) and it was minimum in T_1 (4277 N mm^{-2}). The similar trend was observed in modulus of elasticity along the grain.The modulus of rupture across the grain of Ailanthus plywood was maximum in T_3 (34.68 N mm^{-2}) and minimum in T_1 (29.71 N mm^{-2}). The similar trend was noticed in modulus of rupture along the grain.

The higher plywood strength of higher girth class may be due to higher density as there is positive correlation between density and mechanical properties and higher density has a great influence on MOR (Ajayi, 2002; Zheng *et al*., 2007) [1, 15].

Table 5: Mechanical properties of *Ailanthus excelsa* plywood

Treatments (Girth classes)	MOE (across the grain) (N mm^{-2})	MOR (across the grain) (N mm^{-2})	MOE (along the grain) (N mm^{-2})	MOR (along the grain) (N mm^{-2})	Glue shear strength (N mm^{-2})
T_1 (30-45cm)	4277	29.71	6150	39	1119
T_2 (45cm-90 cm)	4962	32.70	6401	42	1219
T_3 (90 cm- 120 cm)	5024	34.68	6436	48	1318
SEd	9.903	0.555	3.685	0.186	2.766
CD (0.05)	20.807	1.166	7.743	0.392	5.813

The results showed that the glue shear strength of Ailanthus plywood was significantly higher with a value of 1318 N mm^{-2} in T_3 and it was lower in T_1 (1119 N mm^{-2}).The conclusion which could be drawn from this study is that *Ailanthus excelsa* wood has shown nearer physical and mechanical properties to the IS 1708 standard which is the commonly following standard by all plywood industry. Hence, *Ailathus excelsa* wood could be used as medium density plywood which can be used for light and medium structural work.

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References

1. Ajayi B. Preliminary investigation of cement-bonded particle board from maize stalk residues. The Nigerian Journal of Forestry. 2002;32(1):33-7.
2. Akachuku AE. University of Ibadan, Nigeria. Agric. Research Bulletin. 1980;1(2):5-6.
3. Islam MN, Rahman KS, Alam MR. Comparative study on physical and mechanical properties of plywood produced from eucalyptus (*Eucalyptus camaldulensis*

Dehn.) and simul (*Bombax ceiba* L.) veneers. Research Journal of Recent Sciences. 2012;2277:2502.
4. Barboutis I, Vasileiou V. Physical and Mechanical Properties of *Ailanthus altissima* (Miller) Swingle wood. In Proceedings of the 14th Panhellenic Forest Conference, 2009, 1-4.
5. Fuwape JA, Fabiyl JS. Variations in strength properties of plantation grown *Nauclea diderrichii* wood. Journal of Tropical Forest Products. 2003;9(1/2):45-53.
6. Izekor DN, Fuwape JA, Oluyege AO. Effects of density on variations in the mechanical properties of plantation grown *Tectona grandis* wood. Archives of Applied Science Research. 2010;2(6):113-20.
7. Kumar D, Bhat ZA, Singh P, Shah MY, Bhujbal SS. *Ailanthus excelsa* Roxb. is really a plant of heaven. International Journal of Pharmacology. 2010;6(5):535-50.
8. Saravanan V, Parthiban KT, Thiruneraiselvan S, Kumar P, Vennila S, Kanna SU. Comparative study of wood physical and mechanical properties of *Melia dubia* with Tectona grandis at different Age Gradation. Research Journal of Recent Sciences. 2014;2277:2502.
9. Rahman MM, Das AK, Asaduzzaman M, Biswas SK, Hannan MO. Physical and mechanical properties of Raj Koroi (*Albizia richardiana*) plywood. Afr. J. Wood Sci. For. 2013;2:98-103.
10. Rahman MK, Asaduzzaman M, Rahman MM, Das AK, Biswas SK. Physical and mechanical properties of ghora neem (*Melia azedarach*) plywood. Bangladesh Journal of Scientific and industrial research. 2014;49(1):47-52.
11. Saravanan V, Parthiban KT, Thiruneraiselvan S, Kumar P, Vennila S, Kanna SU. Comparative study of wood physical and mechanical properties of *Melia dubia* with *Tectona grandis* at different Age Gradation. Research Journal of Recent Sciences. 2014;2277:2502.
12. Shukla KS, Shukla LN. Plywood from Indian Timbers: *Lagerstroemia parviflora* (Lendi). Indian Forester. 1989;115(3):168-76.
13. Tenorio C, Moya R, Muñoz F. Comparative study on physical and mechanical properties of laminated veneer lumber and plywood panels made of wood from fast-growing *Gmelina arborea* trees. Journal of wood science. 2011;57(2):134-9.
14. Uday DN, Sujatha D, Pandey CN. Suitability of *Melia dubia* (malabar neem wood) for plywood manufacture. Journal of the Indian Academy of Wood Science. 2011;8(2):207-11.
15. Zheng Y, Pan Z, Zhang R, Jenkins BM, Blunk S. Particleboard quality characteristics of saline jose tall wheatgrass and chemical treatment effect. Bioresource Technology. 2007;98(6):1304-10