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Utilization of Pitali *(Trewia nudiflora)* for Manufacturing Commercial Plywood in Bangladesh

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Abstract

The study was conducted to find out the potentiality of Pitali (*Trewia nudiflora*) for manufacturing commercial plywood and evaluating its physical and mechanical properties. Two 9-ply plywood of 2.4m x 1.2m x 18mm size were manufactured using liquid urea formaldehyde adhesive. The physical and mechanical properties of *T. nudiflora* plywood were compared with the existing market available plywood manufactured by Simul (*Bombax ceiba*). It was found that density were 509.82 kg/m^3 and 490.96 kg/m^3, moisture content after curing were 10.67% and 17.61%, thickness swelling were 6.90% and 7.29%, linear expansion were 0.19% and 0.15%, water absorption were 50.89% and 64.79%, MOR were 29.94 N/mm^2 and 27.05 N/mm^2, MOE were 1613.89 N/mm^2 and 1160.68 N/mm^2, and tensile strength were 14.75 N/mm^2 and 13.12 N/mm^2 for *T. nudiflora* plywood and market plywood respectively. The evaluated physical and mechanical properties of *T. nudiflora* plywood were also compared with some relevant results and standards reported earlier.

Key Words: Plywood, Trewia nudiflora, Physical properties, Mechanical properties.

Introduction

Wood is one of the earth's most valuable resources and it conforms to the most varied requirements. It is the principle raw material for manufacture of plywood besides adhesives. But all timber species are not equally suitable for large scale manufacture of any type of plywood for the reasons of physical character of timber, its availability in bulk quantity and price factor (Zaman, 1982). About 70% demand for timber and 90% for fuel wood of the country is met from the trees grown in the village groves of Bangladesh (Anon, 1987). There are about 150 tree species grown in the homestead and village groves of Bangladesh (Das, 1990). Only a few of them are being used by the

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plywood, tea chest and particleboard industries. 16 timber species are recommended for decorative veneer and decorative plywood (Anon, 1986), 17 for marine plywood (Anon, 1985), 46 for manufacture of ply for general purposes (Anon, 1983), 36 for plywood and battens for tea chest (Anon, 1979). These timber species make the total of 120 which practically come from 55 timber species out of the 500 hardwood timber species available in the forest of Bangladesh (Sheikh et al. 1993). The wood species for commercial plywood should be soft to moderately hard depending on the purpose of use and be more or less decorative in figure. Gamar (*Gmelina arborea*), Champa (*Michelia champaca*), Chapalish (*Artocarpus chaplasha*), Haldu (*Adina cordifolia*), Toon (*Cedrela toona*), Teak (*Tectona grandis*), and Mahogany (*Swietenia mahagoni*) are some of the established timber species of Bangladesh for commercial plywood (Azizullah, 1982). All these species are now short supply because of their extensive extraction and over exploitation (Ashaduzzman and Sharmin, 2007). To reduce the pressure on these species and to fulfill the demand of the plywood industries it is of paramount importance to introduce alternative species for manufacturing commercial plywood.

Pitali (*Trewia nudiflora*) is a moderate sized to large deciduous tree, often with a short bole and spreading branches, but under favorable conditions producing a long clear bole. *T. nudiflora* distributed of Sub-Himalayan tract from immediately west of the Jamuna eastwards, West Bengal, Assam, Burma, Nagpur and the Indian Peninsula, chiefly in moist forests and particularly along steams and in moist and swampy situations (Troup, 1986). It grows in low lying areas, along the swamps in all districts of Bangladesh. Freshly cut wood is white or cream colored, turning grayish brown or yellowish on age, often discoloration by fungal sap stain. Wood is soft and light, fine even textured, straight grained (Alam *et al*. 1991). Specific gravity of *T. nudiflora* wood is 0.400, 0.419, and 0.441 of green, air dry and oven dry condition respectively. In Bangladesh *T. nudiflora* used for fuel wood, match boxes, slate, picture frames, agricultural implements, toys, planking, and carved images, and has been reported suitable for match manufacture. In order to introduce *T. nudiflora* as a new source of raw material for commercial plywood and evaluating its physical and mechanical properties of the manufactured plywood, the present study was conducted.

Materials and Methods

Collection and preparation of raw materials

Two Pitali (*T. nudiflora*) trees were collected from homestead forest of Patibila Union of

Jessore district in Bangladesh. The age of the trees was approximately 7 years. The height and girth of the trees were varied from 8 m to 8.5 m and 82 cm to 85 cm respectively. While making selection, trees with excessive clean, straight bole and small knot around the circumferences were included. Logs were stored only 37 hours in the open air, as fresh logs when processed, yield clean uniform veneers which bond well. The logs were cross cut lengthwise by saw to convert into 1.35m bolts for peeling. The bolts were then debarked for veneer production.

Manufacture of plywood

All the bolts were peeled without any pre-treatment. The veneers were produced from bolts in a veneer lathe. The bolts were peeled into 2.5 mm thick veneer and the knife-angle was adjusted to 90^{O}. The rotary cut veneers were then clipped on both edges to produce 2.4 m x 1.2 m (8 ft. x 4 ft.) size veneer. The wet rotary-cut veneers were dried in Danvo Drive Motor drier for 39 minutes at 120^{O}C temperature. Liquid urea -formaldehyde adhesives were used for bonding the plies together. Adhesives were spread on alternative layers of ply by glue spreader. 4.8 kg adhesives were used for making each panel (2.4 m x 1.2 m). In preparing the adhesive mix, the adhesive was extended with 0.709 kg flour, melamine and granulated nut cell powder; catalyzed with 0.0152 kg ammonium chloride as hardener and 0.076 kg preservative (Dursban). The glue coated veneers were allowed assembly time for 25 minutes between the spreading of adhesive and the application of pressure. For making 18 mm thick plywood, 7 plies of 2.5 mm thick *T. nudiflora* were assembled as core and 0.35 mm thick Garjan (*Dipterocarpus turbinatus*) plies were assembled as face and back. Garjan plies were widely used in the country for producing commercial plywood because of its decorative purpose and high strength values. The assembled veneers were pressed in a multi-platen hot-press for 19 minutes at 120^{O}C temperature and 14.5 kg/cm^2 pressure. The panels were finally trimmed to 2.4 m x 1.2 m (8 ft. x 4 ft.) dimension by circular saw because this dimension is commercially used in the existing plywood market. After proper surface finishing the panels were stored for 29 hours under conditions that was not appreciably changed the moisture content.

Preparation of test samples

In order to prepare the test samples for determining the physical and mechanical properties of the manufactured plywood, 49.39 x 48.65 mm and 400 x 50.73 mm size samples were converted form the manufactured board respectively. Tests were conducted at room temperature 22^{O}C.

Determination of the physical and mechanical properties

In case of physical properties of the manufactured plywood, density was measured on oven-dry weight and oven-dry volume and moisture content was measured by oven-dry method (Franz *et al.* 1975). Thickness swelling and linear expansion were measured by the dimensional changes of test samples in water immersion for 24 hours. The water absorption was measured followed by the weight changes before and after immersion in water for 24 hours (Franz *et al.* 1975). Regarding the mechanical properties, the bending strength of the panel i.e. modulus of rupture (MOR), modulus of elasticity (MOE) and tensile strength were measured in universal testing machine (UTM) followed by the standard testing methods (Desch and Dinwoodie, 1996).

Results and Discussion

The peeled veneers were smooth and of acceptable quality. T. nudiflora peels easily and without any pre-treatment giving pale yellow, straight grained and rough veneer. Veneer produced by rotary-cutting, had moisture content range from 51% to 53%. Only properly dried veneer can be glued and protect it from mould or fungal attack or staining. Thus, quick drying is necessary, and for gluing with urea-formaldehyde resin, 8% to 12% moisture content of the veneer is required (Franz *et al.* 1975). The green veneers dries moderately easily and reduce the moisture content 4% to 6%. The dried veneer glued easily and indicates that UF bonded plywood was of acceptable qualities. The evaluated physical and mechanical properties of the manufactured plywood were given in table 1 and table II. Regarding the comparison of the qualities of the Pitali plywood with that of the existing market plywood manufactured from Simul (*Bombax ceiba*) of same dimension and thickness were evaluated. The physical and mechanical properties of the simul plywood are also presented in the same tables.

The revealed physical properties of Pitali (*T. nudiflora*) and market (B. ceiba) plywood were density 509.82 and 490.96 (kg/m^3), moisture content after curing 10.67 and

Table I. Physical properties of pitali and market plywood.

Species	Thickness (mm)	Density (kg/m^3)	Moisture content (%)	Thickness swelling (%)	Linear expansion (%)	Water absorption (%)
Trewia nudiflora	18	509.82	10.67	6.90	0.19	50.89
Bombax ceiba	18	490.96	17.61	7.29	0.15	64.79

Table II. Mechanical properties of pitali and market plywood.

Species	Thickness (mm)	MOR (N/mm^2)	MOE (N/mm^2)	Tensile strength (N/mm^2)
Trewia nudiflora	18	29.94	1613.89	14.75
Bombax ceiba	18	27.05	1160.68	13.12

17.61%, thickness swelling 6.90 and 7.29%, linear expansion 0.19 and 0.15% and water absorption 50.89 and 64.79% respectively. The revealed mechanical properties were modulus of rupture (MOR) 29.94 and 27.05 (N/mm^2), modulus of elasticity (MOE) 1613.89 and 1160.68 (N/mm^2) and tensile strength 14.75 and 13.12 (N/mm^2) for Pitali plywood and market plywood respectively. Most of the physical properties i.e. density, moisture content, thickness swelling and water absorption except linear expansion and all the mechanical properties of Pitali plywood showed greater values than that of market plywood. Analysis of variance of the different physical and mechanical properties of the Pitali plywood and market plywood were studied and summaries are presented in the table III.

From the analysis of variance, significant variation has been found in density, moisture content, linear expansion and water absorption but insignificant variation has been found in thickness swelling between Pitali plywood and market plywood. On the other hand mechanical properties i.e. MOR, MOE and tensile strength showed significant variation between Pitali plywood and market plywood.

In comparison of the results of physical and mechanical properties of Pitali (*T. nudiflora*) plywood and existing market plywood, it was found that most of the physical and mechanical properties of Pitali plywood were significantly higher than market plywood. Some of the physical properties of Pitali plywood were compared with the

Table III. Summaries of analysis of variance of the physical and mechanical properties between pitali plywood and market plywood.

Source of variation	F-rations and statistical significance							
	Density	MC	Thickness swelling	Linear expansion	Water absorption	MOR	MOE	Tensile strength
Species	17.59*	51.83*	0.78 ns	5.10*	60.53*	15.19*	184.75*	16.58*

Note: * = significant at 95% probability level, with 1 and 22 degree of freedom; ns = not significant results reported earlier (Franz *et al.* 1975) and some of the mechanical properties were compared with American Society for Testing and Materials (ASTM) Standards. Franz *et al.* (1975) described the density range of the standard plywood from 430 kg/m^3 to 794 kg/m^3 and the moisture content of the standard plywood after storage in normal climate from 7.3% to 12.7%. The density (509.82 kg/m^3) and moisture content (10.67%) of pitali plywood is quite similar to these values. According to ASTM Standard, modulus of rupture of standard plywood varied from 20.7 to 48.3 N/mm^2 (ASTM, 1987) and its value is quite similar to the modulus of rupture of Pitali plywood, 29.94 N/mm^2. Again, according to ASTM Standard, tensile strength of standard plywood varied from 10.3 to 27.6 N/mm^2 (ASTM, 1990) and its value is quite similar to the tensile strength of pitali plywood, 14.75 N/mm^2.

Conclusion

Plywood industries are established to reduce pressure on solid wood. But at present plywood industries are suffering from scarcity of raw materials because a few species like Anthocephalus chinensis, Alstonia scholaris, and Bombax ceiba are commercially used for plywood production. Scientific usage of non valuable timber species for plywood manufacture can give potential solution of this problem. Plywood manufactured from pitali (*T. nudiflora*) was satisfactory and acceptable quality. The evaluated physical and mechanical properties was significantly higher than that of existing market plywood and it is acceptable comparing with some standards and results reported earlier. So utilization of *T. nudiflora* for manufacturing commercial plywood will be an appropriate alternate source of raw material for plywood industries in Bangladesh.

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