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Research Article

Suitability of Manufacturing Furniture from Toon (*Cedrela toona*) Wood in terms of Exhibiting Some Machining and Handtool Properties

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Abstract

Toon wood (Cedrela toona) is less known in Bangladesh as a commercial timber species, but it also has the prospects of being used for joinery, musical instruments, and some specific furniture manufacturing purposes depending on its physical and mechanical properties. This study was intended to identify the compatibility of Toon (Cedrela toona) wood for furniture manufacturing in terms of exhibiting some machining and handtool properties viz., planning, shaping, boring, mortising, and turning tests. The appraisal in both machining and handtool property tests were based on the frequency of the defect-free samples. The finishing property was also ascertained by using two types of polishing materials, viz., carpa and shellac. The defects of the samples were conjectured by visual and tactile observation. The percentage of defect-free samples was assessed for each property operation and classified based on five quality grades. The results of this study mainly emphasized good working properties, and toon wood may be suitable for furniture manufacturing.

সারসংক্ষেপ

এই গবেষণায় তুন কাঠের কিছু মেশিনিং এবং হ্যান্ডটুল গুণাগুণ, যেমন: প্লেনিং, শেপিং, বোরিং, মর্টাইজিং এবং টার্নিং প্রভৃতির উপর ভিত্তি করে উক্ত কাঠ দিয়ে আসবাবপত্র তৈরীর উপযুক্ততা নিরূপণ করা হয়েছে। মেশিনিং এবং হ্যান্ডটুল উভয় পর্যবেক্ষণের ক্ষেত্রেই ত্রুটিমুক্ত নমুনার প্রাপ্যতার ভিত্তিতে চূড়ান্ত ফলাফল নির্ধারণ করা হয়েছে। দুই ধরণের পলিশিং পদার্থ, যথা: কার্পা এবং শেলাক ব্যবহার করেই পলিশিং গুণাগুণ মূল্যায়ন করা হয়েছে। শতকরা হিসেবে প্রাপ্য ত্রুটিমুক্ত নমুনার প্রতিটি গুণাগুণ চাক্ষুষ এবং স্পর্শন দ্বারা নির্ধারণ করা হয়েছে এবং পাঁচ প্রকারের গ্রেড অনুযায়ী শ্রেণিকরণ করা হয়ছে। এই গবেষণা কার্যক্রমটি মূলত সকল গুণাগুণের সন্তোষজনক ফলাফলের ভিত্তিতে তুন কাঠ দ্বারা টেঁকসই এবং মানসম্মত আসবাবপত্র তৈরীর বিষয়ে অনুপ্রাণিত করেছে।

Keywords: Boring, Carpa, Machining, Planing, Mortising, Shaping, Shellac, Turning.

Introduction

Cedrela toona Roxb., a medium- to large-sized deciduous tree with a brown to gray scaly bark, 18 to 21m tall and with a diameter of 0.57 to 0.95m. The crown is broad and rounded. The leaves are compound 30 to 55cm long. It has a

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single stem or trunk and branches that support leaves. Beneath the ground, a tree has a root system that acts as an anchor and store the water and nutrients the plant needs to grow (Khan 2022). Seeds have wings on both ends and are elliptic-shaped, measuring 10–20mm long and 6–8mm in diameter (Shah and Patel 2021). Since the beginning of time, wood has served as a raw material for man, providing benefits that have helped him survive and build civilizations. It is also true that wood is the most typical foundational material for various things, despite being disregarded today due to the advent of synthetic substances. By using cutting-edge research techniques to examine this natural source of material's growth, structure, chemical composition, and exploitation, it's worth is preserved and increased. There are numerous cutting-edge uses for wood. The wood is processed into a veneer from the creation of buildings, furniture, pillars, and other everyday items, which is then glued to plywood, constructions (such as beams, arches, and helicopter propellers), etc., typically using waterproof adhesives (Namichev *et al.* 2019).

The analysis of the wood and all of its features, from physical, chemical, and mechanical to ergonomic, wear, surface coatings, and other factors, is the essence of how wood influences the technological processes involved in the furniture-making process. Each type of wood has specific characteristics and flaws, and by considering this in mind, it may be influenced technological advancements to boost yield and cut expenses while accomplishing more work in a shorter amount of time. Today's finest furniture is often manufactured from wood. Every home is required to utilize wood because of its innate advantages, attractive appearance, and inherent characteristics (Namichev *et al.* 2019). Traditional wood, in its original aspect, will increase in value and esteem in the future. The production of elegant instruments and furniture, as well as the making of sculpture and carvings, will be bestowed even more respect on the cultural hierarchy (Namichev *et al.* 2019). Wood tends to be used less for products that retain their original structure, but there is a noticeable increase in products that involve mechanical or chemical modification of the wood. These wood-based items are anticipated to represent the majority of wood utilization in the future (Namichev *et al.* 2019). Toon wood is a fragile, unstable, and lightweight form of timber. Lightweight furniture, doors, panels, windows, tea boxes, boat equipment, toys, carving goods, musical instruments, etc. can all be manufactured out of it (Sarker *et al.* 2021). The demand for wood products is gradually increasing due to the rapid growth of the population in Bangladesh. The distinction that exists between a resource and a necessity is very significant. As a result, our forest resources are becoming less accessible with each passing day (Biswas *et al.* 2017). Evaluating the effects of wood machining characteristics (for planing, shaping, boring, mortising, and turning) on surface quality requires determining and enhancing wood machining properties as well as defining convenient usage areas for several unconventional wood species found in Bangladesh (Sofuoglu and Kurtoglu 2014). Therefore, the working and finishing characteristics of this wood are essential to explore as an alternative source to conventional timber species and enhance its economic value.

Materials and Methods

To conduct this study, toon wood were procured in the log form from the Lama upazila of Bandarban district for the test. The logs were converted to planks and sawing quality was determined. Samples, 25.4mm × 127mm × 1219.2mm in size were made out of wood species. Before conducting the tests, these samples were seasoned to 12-15% moisture content and were again converted into smaller pieces suitable for different tests. The samples were immediately examined visually to sort out the defect-free ones. After completing tests, samples were classified based on five quality grades (Table 1). The percentage of defect free samples based on total samples was determined. The percentage was considered as the measure of its property quality. The tests were carried out by ASTM Standards: D-1666-64 (Anon 2004). Similar property tests were conducted using carpenter's handtool, and it was accomplished at Bangladesh Forest Research Institute, Chattogram (during July 2020 to June 2022).

Planing and finishing test

The test samples for planing and finishing property was 25.4mm × 101.6mm × 914.4mm in size. The test was carried out in a Whitney No. 105 single surface planer with four straight knives. The cutter head speed was 3000 rpm. The depth of cut was 1.59 mm for all runs. The feed rate was adjusted to 636 mm per minute so that the target number of knife marks was 40 per 25.4mm. The run was made with a sharpness angle of 30 degrees and cutting angle of 25 degrees. The exact number of samples was tested with the carpenter's hand planner, and a similar testing procedure was applied. The planning test samples were used for the test of finishing after completing all planning property tests. In the finishing test, two polish types, namely shellac and carpa were applied, and performance was recorded based on the surface finish and physical appearances.

Boring test

The size of the test for boring property was 25.4mm × 76.2mm × 304.8mm. The test was conducted in a 508mm single spindle hand feed drill press of Walker Turner Model No. 1113-41. A one-inch single twist solid center bred point type wood boring bit was used for the test. The drill machine was adjusted to maintain a spindle speed of 2850 rpm. In terms of handtool property test, boring was done by a carpenter's hand drill. A one-inch single twist solid center screwed point type

Table 1. Performance-wise quality grades of all property tests.

Defects	Performance	Quality Grade
No defect	Excellent	1
Few slight defects	Good	2
Lots of slight defects	Fair	3
Serious defects	Poor	4
Very serious defects	Very poor	5

wood boring auger bit was used for the test. A solid hardboard was used as backing underneath to avoid the tearing and splintering of samples at the bottom during boring both for machining and handtool test.

Shaping test

The test samples used for boring were also used for carrying out shaping tests of machining and handtool, respectively. The test was carried out in a hand-fed single spindle shaper of J.A.Fay and Egan Company, Model No. 252, with two knives having a spindle speed of 6500 rpm. Here the cutting angle was 25 degrees. The cutter used to obtain a quarter round pattern had a radius of curvature of 12.7mm. In case of handtool test, ripping of the sample was done by carpenter's handsaw to obtain the quarter round pattern. The shaping was carried out by carpenter's chisel of half-round type.

Mortising test

The samples used for boring and shaping tests were also used for the mortising test. Machining and handtool property tests were ascertained from the separate samples. It was used as hardboard backing when mortises were cut on each sample. Each mortise was cut with two sides parallel to the grain and perpendicular to the grain. The machining test was carried out in a foot feed vertical square hollow mortising chisel of Oliver Machinery Com., Model No. 91D. The spindle speed of the drill machine was 3600 rpm. A one fourth inch square chisel was applied in this property test.

Turning test

The size of the test samples used for turning property was 25.4mm × 25.4mm × 152.4mm. The test was carried out in a variable speed wood lathe of Oliver Machinery Com., Model No. 159A. The speed of the variable lathe was 2400 rpm. A set of high-speed steel cutter were used to give head and cove for having different turning features and the ability to cut at different angles with the grain.

Statistical analysis

The data were analyzed using Microsoft Excel Spreadsheet and SPSS version-22.

Results

In conformity with the variation of grain orientation and the load applied to the saw blade, toon wood required less pressure on the saw blade, which exhibited easy to saw (Table 2). The fiber and grain structure of wood determine the type of wood as well as the quality of sawing and finishing. According to specific gravity, this wood responded as light timber. A comparison of the defect-free samples as a percentage among three wood species, both in machining and handtool testing, has been presented (Fig. 1 & Fig. 2). The percentage of raised grain, fuzzy grain, tear-out, and broken corner defects taken from the total number of samples of toon wood in both machining and handtool tests is displayed (Fig. 3 & Fig. 4). The grade-wise performance of different machining and handtool property tests of toon wood based on the number of defect-free samples as a percentage has been displayed in Table 3. All kinds of finishing quality of toon wood showed promising results.

Table 2: Specific gravity, age, sawing and finishing quality of wood species

SI. No.	Property/Parameter	Value/Quality	Remarks
1	Age of the tree	30 to 35 (Years)	According to annual growth rings
2	*Specific gravity (Green condition)	0.40	Light timber
3	*Specific gravity (Oven-dry condition)	0.48	
4	Finishing quality	Good	Two types of polishing
5	Sawing quality	Easy	According to load application

*Data source: Sattar *et al.* 1999

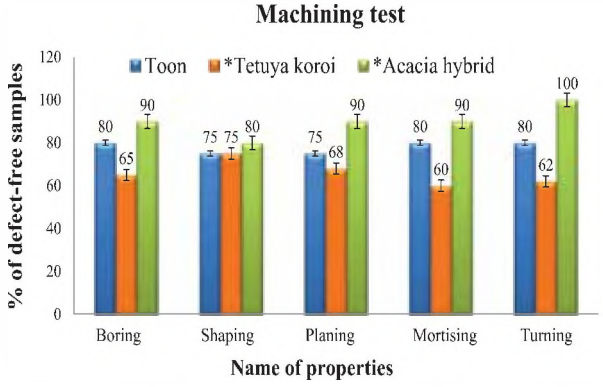

Figure 1. Comparison of the number of defect-free samples as a percentage among three wood species in machining test.[*Data source:(Sarker *et al.* 2021)]

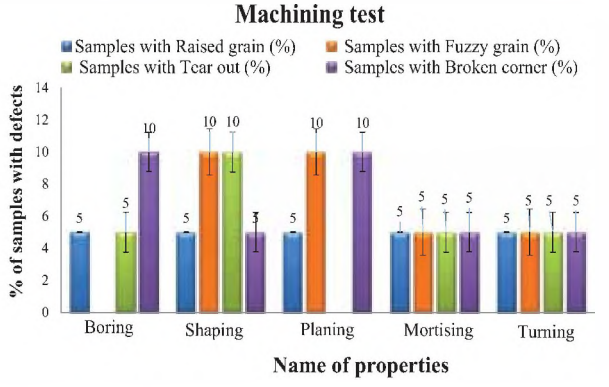

Figure 3. Percentage of raised grain, fuzzy grain, tear-out, and broken corner defects taken from the total number of samples of toon wood in machining test.

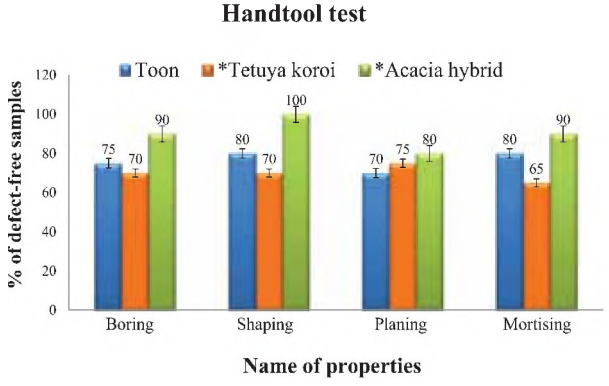

Figure 2. Comparison of the number of defect-free samples as a percentage among three wood species in handtool test.[*Data Source: (Sarker *et al.* 2021)]

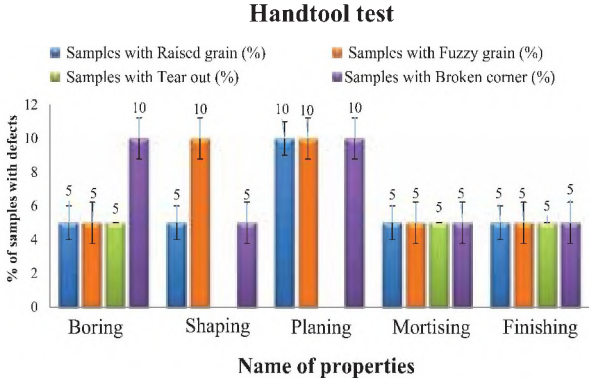

Figure 4. Percentage of raised grain, fuzzy grain, tear-out, and broken corner defects taken from the total number of samples of toon wood in handtool test.

Table 3. Grade-wise performance of different machining and handtool property tests of toon wood based on the number of defect-free samples as a percentage.

Property		Number of tested samples	Percentage of property tests leading to Grade 1 quality
Name	Type		
Planing	Machining	20	75
	Handtool	20	70
Shaping	Machining	20	75
	Handtool	20	80
Boring	Machining	20	80
	Handtool	20	75
Mortising	Machining	20	80
	Handtool	20	80
Turning	Machining	20	80

Discussion

Since Lambu (*Khaya anthotica*) wood was light, sawing was made less difficult since less force was needed on the edge of the blade. In addition, as Jhau (*Casuarina equisetifolia*) wood was heavy and hard, sawing it was tough (Sarker *et al.* 2015). During property evaluation of Mahogany (*Swietenia macrophylla*) wood, it displayed 100% qualified grade in all machining and handtool tests except for machining property of planning operation which rated 95% qualified grade (Sarker *et al.* 2019). But during the evaluation of all the properties of toon wood, both for machining and handtool tests, 70 to 80% of the tested samples exhibited grade 1 quality. Based on comparisons of the defect free samples for different property operations, Toon wood illustrated comparatively better quality in both machining and handtool test than Tetuya koroi (*Albizia odoratissima*) wood which also displayed good quality whereas Acacia hybrid (*Acacia mangium* × *Acacia auriculiformis*) showed an excellent quality of property results in most cases (Sarker *et al.* 2021). The most common defects of planning tests both for Tetuya koroi (*Albizia odoratissima*) wood and Acacia hybrid (*Acacia mangium* × *Acacia auriculiformis*) were fuzzy grains (Sarker *et al.* 2021). On the other hand, in this study, the observable defects of toon wood both for machining and handtool tests were due to fuzzy grains and broken corners, whereas defects due to raised grains and tear-out were less significant. Sharpened cutters and robust, well- maintained machines are mandatory for the finest machining of the material. With several blades placed inside the blade head, all cutters should be used uniformly (Sofuoglu and Kurtoglu 2014). In general, unusual wood with gelatinous fibers those shrink and expand more than regular wood when the moisture content changes are linked to fuzzy grain. Low rake angles, sanding, dull blades, and other similar factors are frequently related to raise grain. The moisture content of various species

has numerous impacts on the previously mentioned wood machining defects. For instance, raised grain may appear through machining wood at high or low moisture content and then adjusting the moisture content due to the unequal shrinkage and swelling of the early wood and latewood. Fuzzy grains may appear as the moisture content increases. In general, machining defects can be reduced by variations in the moisture content. Minimizing machining defects can be achieved by machining wood at its optimum moisture content (8-12%) and then preserving it there while in use (Harold 1980). When considering wood as a structural element, the moisture percentage is a crucial factor. The future performance of wood within a structure is impacted by its moisture content (Malesza 2015). Visual inspection presented the basis on assessing machining imperfections. However, it proved incapable to precisely evaluate them. An in-depth investigation of the machining experiments could not be performed due to equipment deficits. Further investigation is still required for the best findings (Sarker *et al.* 2019). The wooden materials are supposed to have a smooth grain and be free of knurls or other structures that can cause grain deviations (Sofuoglu and Kurtoglu 2014). In this research, there was found got overall satisfactory results in both machining and handtool property tests of toon wood, which encouraged the people to use this wood species as an alternate to be used for domestic furniture making and other utilization purposes.

Conclusion

Wood-based household furniture is an intimate part of every family as a symbol of necessity and aristocracy. But it may not always be possible for most of the people in our country to decorate their houses with furniture manufactured from so-called expensive traditional timber species. Hence, it would be a better substitute for manufacturing sustainable and remunerative furniture from toon wood, thereby reducing pressure on conventional timber species. Further investigation might be needed to get information regarding the load bearing capacity and durability of the manufactured furniture.

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