

Machining and Related Handtool Properties of Rajkoroi (*Albizia richardiana*) Wood and Its Suitability as a Furniture Material

Md. Ashaduzzaman Sarker*, Md. Nazmul Ahasan Mridha, Tapas Kumar Dey, Md. Abdul Khaleque

Wood Working and Timber Engineering Division, Bangladesh Forest Research Institute (BFRI), GPO Box No. 273, Chattogram-4000, Bangladesh

Corresponding author's email address: asad.bfri@gmail.com

Abstract The study was carried out to determine boring, mortising, planing, shaping etc., machining and handtool properties of rajkoroi (*Albizia richardiana*) wood species grown in southern part of Bangladesh and to assess its suitability for furniture manufacturing. Finishing property was also determined with the implement of two types of polishes, namely – carpa and shellac. In both machining and handtool tests, the evaluation of the properties was based on the frequency of defects of the samples. Defects of the samples were visually and tactilely inspected. Each sample was categorized on the basis of five quality grades according to estimated defects for each property test. Various types of furniture were manufactured with this wood after treating 10% borax-boric acid preservative solution and put under service test. The study result showed that all property exhibited 40% to 95% grade A and 05% to 35% grade B. No property yielded any percentage of grade E result. From the study findings, the rajkoroi (*A. richardiana*) wood introduced overall good quality, and this wood could be suitable for the material of furniture as the furniture were not attacked by any wood deteriorate agent or were not made any deformation.

Keywords Boring, Finishing property, Mortising, Planing, Shaping

1. Introduction

Rajkoroi (*Albizia richardiana*) grows naturally in Australia, Asia, America, Africa and Madagascar. This species belongs to Mimosoideae subfamily of the Fabaceae family [1-3]. This is a fast growing, dichotomously branched and evergreen tree species which can fairly tolerate drought. It demands light but tolerate medium shade in the pole stage [4-5]. This tree species is locally known as chambal, and it is a promising fast growing species with shallow root system [6]. In Bangladesh, it was started to plant in late nineteenth century as an avenue tree. It is being cultivated along the roadsides, parks and gardens and common in homesteads in Bagerhat, Barguna, Barisa, Jhalkathi, Madaripur, Patuakhali and Pirojpur districts of Bangladesh [7]. Rajkoroi is popular to the farmers for its fast growing nature, and they can quick return from cultivating this tree species. On the other hand, some local people plant it as an ornamental tree for making their gardens, parks or roads much more attractive.

Wood is particularly considered as the fundamental and prime material for the mankind survival and the civilization improvement [8]. Wood is traditionally used as the main raw material for furniture and joinery industries. In comparison with plastic and metal products, easy machinability of wood is one of the most important convenience [9]. Wood is extraordinary material because of its availability in different forms and sizes and low cost [10]. There is no home, office, restaurant, or any kind of institution where furniture is not



used by lower to upper classes in villages, towns or cities. Thus, it is highly important to evaluate working properties and relate them to wood characteristics for its proper utilization.

Since the population increases, the internal demands for forest resources are being increased tremendously in Bangladesh. That is why, the gap is raising between the incremental rate of the demands and the supply of natural resources, and forest resources are becoming scarce day by day [11]. Rajkoro wood is used for frame manufacturing, house posting, roofing, etc. [12]. Nowadays, rajkoro wood is available in southern part of Bangladesh, and it is being mostly used as fuel material. But, no working property of this wood species has been determined, and the users do not have any knowledge so that they can use this wood properly. On the other hand, as we have limited forest resources in our country, we should pay attention to utilize them properly. Therefore, working properties of this wood are very needed to identify as an alternative to conventional timber species for magnifying its economic value. As a part of this target, the study was undertaken to determine some machining and related handtool properties of this wood species and evaluate the service test result after making furniture.

2. Materials and methods

For the experiment, the wood of the rajkoro (*Albizia richardiana*), main stem portion, was collected from Barishal district of Bangladesh located in between $22^{\circ}27'$ and $22^{\circ}52'$ north latitudes and in between $90^{\circ}01'$ and $90^{\circ}43'$ east longitudes. The logs were sawn and the lumbers were seasoned to about 12% moisture content for the test of machining, hantool and finishing properties at Bangladesh Forest Research Institute, Chattogram. The study was carried out during July 2006 to June 2011. The sawing quality was evaluated after converting this wood into different sizes. Twenty samples of $26 \text{ mm} \times 127 \text{ mm} \times 1234 \text{ mm}$ in size were prepared. Again, these samples were converted to smaller pieces remaining same (2.6 cm) thickness before conducting different property operations as illustrated in Figure 1. All the samples for the different property tests were sound and free from defects.

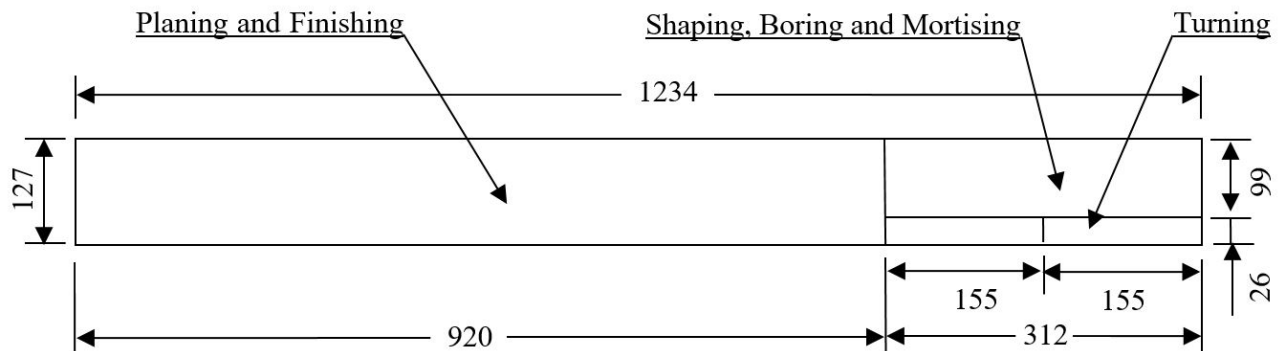


Figure 1: Sample dimensions in mm for different property tests

The property test samples were visually and tactilely examined for sorting out defect variations immediately after finishing the machining operations. After that, all the test samples classified on the basis of different five quality grades (Table 1). The machining property tests were carried out in accordance with ASTM 1666-64 [13]. Same property tests were similarly executed using carpenter's handtools. Different properties of this wood were evaluated at WWTED, BFRI, Chattogram during July 2006 to June 2008. Then, various furniture were fabricated with this wood during July 2008 to June 2011, and all of those furniture have been placed for service test at different location since then. Five chairs without handle and one half-secretariat table have been manufactured at WWTED, BFRI, Chattogram, and one cot, one full-secretariat table and one computer table have been manufactured at PTUD, BFRI, Barishal during July 2008 to June 2009. Ten chairs with handle and other fifty furniture items have also been fabricated with this wood at PTUD, BFRI, Barishal during July 2009



to June 2010 and July 2010 to June 2011 respectively. Before manufacturing the furniture, the wood was treated by 10% borax-boric acid solution. The treatment method was soaking and the duration of treatment was for seven to ten days.

Table 1: Defect wise quality grades of different property operations

Defects (%)	Performance	Quality grade
0	Excellent	A
01 – 25	Good	B
25 – 50	Fair	C
50 – 75	Poor	D
75 – 100	Very poor	E

Planing and Finishing Test

The planing test was accomplished in a Whitney No. 105 Single Surface Planer. This planer machine had four knives with a cutter heed speed of 3000 rpm and feed rate of 636 mm/min. The sharpness and cutting angles of the knives were 30 and 25 degrees respectively. A similar number of samples was tested with carpenter's hand planer, and an identical procedure of testing was applied. The samples of planing test were used for finishing property test after completing planing property test. Two kinds of polish such as shellac and carpa were applied to the samples for the purpose of finishing test. In this case, performance was recorded on the basis of surface finish and physical appearances.

Boring Test

With a 508 mm single spindle hand feed drill press, the boring property test was carried out. Two holes were thoroughly bored on each sample. The machine was set to keep up a spindle speed of 2850 rpm. In case of handtool property test, carpenter's hand drill was used in order to do boring. Suitable one-inch wood boring auger bit was utilized in both machining and handtool operations. To avoid tearing and splintering of sample during boring, solid type of hardboard was used as backing underneath the test sample.

Mortising Test

The same samples of boring test were used for the mortising property test of machining and handtool respectively. The mortising test in machining was ascertained in foot feed type of vertical hollow chisel mortiser. The spindle speed was 3600 rpm and the chisel was 12.7 mm for the mortising property test. When two mortises were entirely cutting on each sample, a solid hardboard backing was used in case of machining and handtool operation. Each mortise for the test of mortising was cut with perpendicular to the grain and parallel to the grain of the property sample.

Shaping Test

The samples of the boring and mortising tests were also utilized for the shaping property test. Machining and handtool property operations were carried out from the separate samples for the shaping test respectively. In terms of machining operation, the shaping test was accomplished in a special jig to make a curve pattern shape. A single spindle type of hand feed shaper was used. The shaper had two knives and the spindle speed was 6500 rpm. The cutter was used to shape the sample to a quarter round pattern. Here, the radius of curvature was 12.70 mm and the angle of cutting was 25°. In handtool test, the shaping property operation was conducted by carpenter's half-round type of chisel.



Turning Test

The turning property test was carried out in a wood lathe with a variable speed of 2400 rpm. A single steel cutter with high speed was used to offer head and cove for making various turning features with the property sample grain. In this case, it was not possible to ascertain the handtool property with the limitation of expert workforce.

Furniture Manufacture

For manufacturing furniture, the sized wood was seasoned, and the moisture content was about 15%. Season wood treated by 10% borax-boric acid (BB) preservative solution (1:1) for 7 days. Then the treated wood was kept in a shadow place for air drying until the moisture content reached below 15%. In this study, 69 various types of furniture, viz. chair with handle, chair without handle, reading table, secretariat table, half-secretariat table, computer table, low bench, high bench and cot were manufactured at BFRI, Chattogram in 2010 to 2014 and put under service test at different Govt. organisation. Carpa polish was just applied once after completing of these furniture manufacturing.

3. Results and Discussion

Rajkoroi (*Albizia richardiana*) wood was required medium pressure on the saw blade which indicated medium sawing quality. This wood was moderately heavy. Another available species in Bangladesh such as mango (*Mangifera indica*) was light and it was required less pressure on the saw blade that indicated easy to saw [14]. On the other hand, jhau (*Casuarina equisetifolia*) wood rated hard and heavy; and that is why, it indicated difficult quality to saw [15]. According to the variation of grain structure, specific gravity and strength of the wood species, it is needed to vary the load applied to the saw blade. As a result, we get different quality wood species around us. In terms of finishing quality, rajkoroi wood exhibited good result with the application of polish (Table 2).

Table 2: Sawing and finishing quality, specific gravity, age and type of *A. richardiana* wood

Parameter	Value / Quality	Remarks
Quality of sawing	Medium	According to the applied load
Quality of Finishing	Good	Two types of polish
Specific gravity (Green condition)*	0.63	
Specific gravity (Air-dry condition)*	0.65	Moderately heavy
Specific gravity (Oven-dry condition)*	0.70	
Age of the tree	20 – 25 (Years)	According to annual growth ring

* Data source: STPD, BFRI, Chattogram

Table 2 provides the result of planing, shaping, boring, mortising and turning property for *A. richardiana* wood. In case of machining test, turning property showed the highest 95% excellent whereas planing property indicated the lowest 65% excellent (no defect) quality. Good quality was in 5-20% for different properties. Both planing and boring properties rated the same 10% fair when planing and mortising property exhibited 5% poor and fair quality respectively. In this case, other properties indicated 0% fair and poor result.

Table 3: Performance criteria of different machining and handtool properties for *A. richardiana* wood

Test property		Property grade (%)				
Property	Type	Grade A	Grade B	Grade C	Grade D	Grade E
Planing	Machining	65	20	10	05	00
	Handtool	60	20	20	00	00
Shaping	Machining	90	10	00	00	00
	Handtool	75	10	15	00	00
Boring	Machining	70	20	10	00	00
	Handtool	40	30	20	10	00
Mortising	Machining	85	10	05	00	00
	Handtool	35	35	20	10	00
Turning	Machining	95	05	00	00	00



In terms of handtool operation, shaping rated the highest 75% excellent while mortising exhibited the lowest 35% excellent property result. Good and fair result was in 10-35% and 15-20% for various test properties respectively. On the other hand, any property did not pointed out very poor quality in both machining and handtool properties. For instance, tetuya koroi (*Albizia odoratissima*) wood shows that the highest excellent property is 75% and 76% whereas the lowest excellent property is 63% and 65% in machining and handtool respectively [16]. Another species such as lambu (*Khaya anthotica*) wood reveals 30-90% excellent for different property qualities [15].

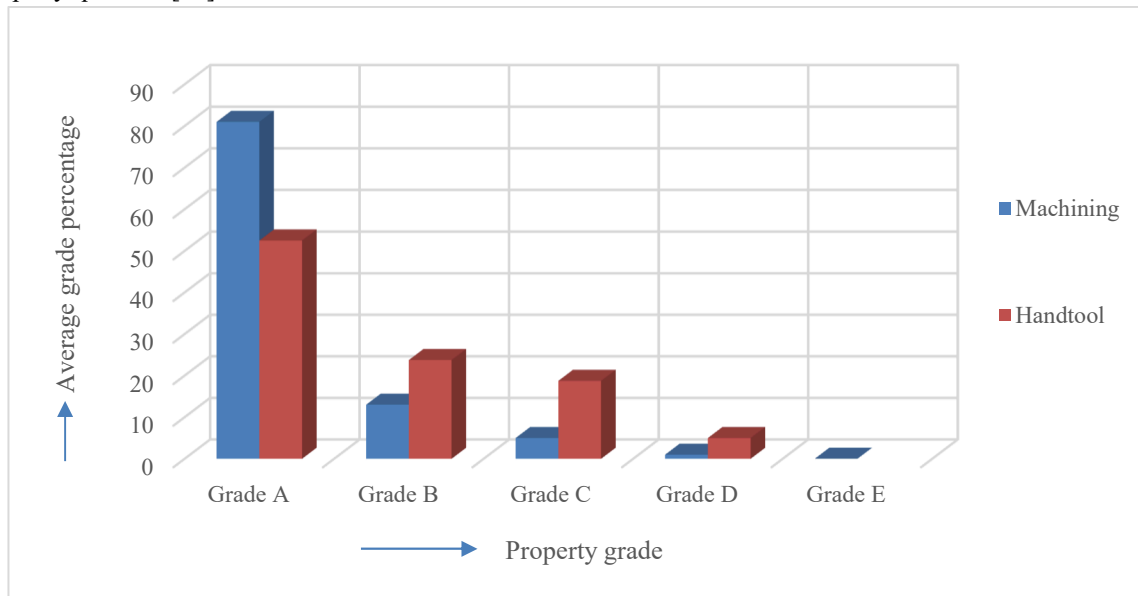


Figure 2: Comparisons of average property grade percentage among different properties

Comparisons of average property grade percentages for different machining and handtool properties have been exhibited in Figure 2. Grade A showed the highest average result 81.00% and 52.50% in machining and handtool respectively while grade E resulted in 0%. It appears that mango (*Mangifera indica*) wood indicates 10% in machining property and 15% in handtool property for grade A [14]. It is also known that lambu (*Khaya anthotica*) wood shows 58.00% and 82.50% grade A in machining and handtool respectively [15]. Furthermore, among grade B, grade C and grade D, the average result of property grade for rajkoroi wood was 1.00-13.00% and 5.00-23.75% in machining and handtool property respectively.

For getting optimum property quality, the equipment for different tests were equipped properly. The major defects of the raj koroi wood in planing test were raised grain. Fuzzy grains and torn grains were also the defects of this property test. Some defects of crashing out and torn grain were in shaping, mortising and turnig property test. For the comparison, it can be shown that mango (*Mangifera indica*) wood has prominent raised grain defects [14]. In terms of tetuya koroi (*Albizia odoratissima*) wood, the defects of machining properties are tear out, raised grain and fuzzy grain, and the defects of handtool properties are broken corner, fuzzy grain and tear out [16]. A few slide defects of fuzzy and raised grain and cutter marks were not considered as defects. These defects could be removed by adequate sanding. As the different property qualities were evaluated by visual and tactile inspection, it was not possible to specify them properly.





Figure 2. Furniture – at (a) Sagordi Union Junior High School, Sagardi, Barishal, (b) WWTED, BFRI, Chattogram (c) STPD, BFRI, Chattogram (d) Bon Gobeshanagar Govt. Primary School, Chattogram (e) Bon Gobeshanagar Govt. Primary School, Chattogram [Photographs captured in October 2020]

Table 4: Service test result of various furniture of raj koroi (*A. richardiana*) wood at different location

Item of furniture	Manufacturing period	Number of item	Servicing place of the furniture	Present condition of furniture
Computer table	2008-2009	1	PTU Division, BFRI, Barisal	No deformation
Full-secretariat table	2008-2009	1	PTU Division, BFRI, Barisal	No deformation
Cot	2008-2009	1	PTU Division, BFRI, Barisal	No deformation
Half-secretariat table	2008-2009	1	STPD, BFRI, Chattogram	No deformation
Chair without handle	2008-2009	5	WWTED, BFRI, Chattogram	No deformation
Chair with handle	2009-2010	7	Sagordi Union Junior High School, Sagardi, Barisal	No deformation
Chair with handle	2009-2010	3	Purbo Harinafuliya Reg. Primary School, Harinafuliya, Barishal	No deformation
Reading table	2010-2011	5	Bon Gobeshanagar Govt. Primary School, Chattogram	No deformation
Chair with handle	2010-2011	5	Bon Gobeshanagar Govt. Primary School, Chattogram	No deformation



Item of furniture	Manufacturing period	Number of item	Servicing place of the furniture	Present condition of furniture
High bench	2010-2011	20	Bon Gobeshanagar Govt. Primary School, Chattogram	No deformation
Low bench	2010-2011	20	Bon Gobeshanagar Govt. Primary School, Chattogram	No deformation

The service test results of different 69 furniture at various location have been presented in Table 4. All of the furniture were used in the usual way, and they have been showing in good condition till now. Especially the furniture which were placed in schools, the colour of those furniture was just faded. And the lower part of the half-secretariat table at STPD was slightly discoloured. No wood deteriorated fungus, borer or termite attacked any rajkoroi furniture kept under service test at different places.

4. Conclusion

The results of the study indicated that the different working properties of rajkoroi (*Albizia richardiana*) wood were of over all good quality, though these property values should be considered as indicatory. The result also showed that different types of seventy-nine furniture of raj koroi wood have still been looked well without any major or even minor deformation. In accordance with the findings, the wood should be utilized as furniture materials. The furniture and other indoor materials form this wood could be substantially long-lasting if treated by chemical preservative properly. Using this rajkoroi wood in case of furniture making would minimize pressure on conventional timber species in Bangladesh. For more information, further investigation should be needed.

Acknowledgements

We would like to express our special gratitude to the authority of Bangladesh Forest Research Institute (BFRI) for facilitating all sorts of support in order to do research on rajkoroi (*Albizia richardiana*) wood species. Secondly, we would also be grateful to Md. Ramiz Uddin, Divisional Officer, Wood Working and Timber Engineering Division, BFRI for his sincere cooperation in doing the research. Finally, we are very thankful to all the colleagues of Wood Working and Timber Engineering Division, BFRI for their cordial research assistance while conducting the study as well.

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